CANADIAN OCCUPATIONS

★

CAREERS

IN

NATURAL SCIENCE AND ENGINEERING

★

MONOGRAPHS 20 - 35

DEPARTMENT OF LABOUR, OTTAWA

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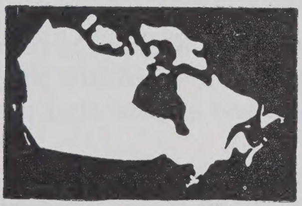

MONOGRAPHS 20 - 35

HON. HUMPHREY MITCHELL, MINISTER
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DEPARTMENT OF LABOUR, OTTAWA

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PREFACE

The importance of the availability of accurate information on occupations, including professional careers, was never so great as it is now. Nowhere is this more necessary than in the case of those professional occupations for which special aptitudes and an expensive academic training are required. Too often faulty advice or misdirected ambition has led many young people to undertake such training, only to find themselves unfitted to complete it.

The Canadian Committee for Student Guidance in Science and Engineering, representing the Engineering Institute of Canada, the Canadian Institute of Mining and Metallurgy, and the Chemical Institute of Canada, has for several years maintained a volunteer counselling service for the assistance of young people contemplating entry into scientific and engineering professions.

This Committee requested the co-operation of the Department of Labour in the preparation and publication of an authoritative reference book to help meet the needs of high school students in selecting their careers and their courses of training. Through the Canadian Council of Professional Engineers and Scientists helpful material was also obtained from the Canadian Society of Forest Engineers, the Royal Architectural Institute of Canada, the Canadian Association of Physicists, and the Agricultural Institute of Canada.

The Department of Labour has been pleased to co-operate with the Committee in this undertaking, especially since this particular project fits into a broad program

of occupational studies being made by our Economics and Research Branch.

Careers in Natural Science and Engineering is intended for the use of counsellors, teachers, secondary school students, and all others interested in the professions covered.

To all members of the professional organizations concerned we should like to express appreciation of the work involved both in planning and preparing this book. We should like also to commend the work of the volunteer counsellors, named by these organizations, who advise youth aspiring to enter these professional fields in all parts of Canada.

The Bureau of Technical Personnel, and the Executive and Professional Division of the National Employment Service, are always at the service of those contemplating entering these professions as well as those engaged in them.

ARTHUR MacNAMARA,
C.M.G., LL.D.
Deputy Minister

HUMPHREY MITCHELL
Minister of Labour

PREFATORY NOTE

The monographs published collectively in this book are part of the series entitled "Canadian Occupations".

The Department of Labour has co-operated with professional organizations in the natural sciences and engineering in preparing these monographs. Most of the material has been prepared by members of these professional organizations. Officers in our Occupational Analysis Section have assisted in the analytical and editorial work.

The Unemployment Insurance Commission and the Bureau of Technical Personnel of the Department of Labour have also made contributions towards the publication of this book.

Unlike the case of many other occupations covered in our "Canadian Occupations" series, pamphlets are not being issued to accompany monographs in this group.

DIRECTOR,
Economics and Research Branch,
Department of Labour.

March, 1949.

CONTENTS

SECTION I

CAREERS IN NATURAL SCIENCE AND ENGINEERING IN CANADA

The monographs in this book, dealing with individual branches of natural science and engineering, define the somewhat specialized fields involved in each branch. There is, however, considerable information which applies generally to many or all of these branches. This has been gathered together to form the opening section which should, in effect, be read as part of the treatment of the subjects dealt with later. An exception is made in the case of architecture which, while it may be said to contain elements of both science and engineering, is an entirely separate profession. The monograph dealing with architecture is therefore complete in itself.

Diversified Nature of Canadian Economy

The scope for a wide variety of careers is as broad in Canada as anywhere else in the world. To begin with, the country is exceptionally well provided with natural wealth under the four main divisions of soil, forests, mines and fisheries. Under each of these classifications our natural resources are characterized by both quantity and variety.

Scientists and engineers have played an important part in the development of Canada. Natural resources have been utilized to make this country one of the leading industrial nations of the world. The progress already made in transportation, communication, agriculture, forestry, mining, manufacturing, power development and construction, points the way to even greater developments in the future. In the planning and execution of such projects, there will be good opportunities for those who can meet the high standards required in these professions.

In all these spheres constant study and research must be maintained in order to seek out additional sources of known materials, to discover new natural wealth and to

exploit the latter efficiently. To process or convert natural products there has been built up in Canada a very substantial manufacturing industry now employing well over 1,000,000 people, and much of this growth has taken place in the last 10 years.

To facilitate travel, whether for business purposes or otherwise, and to move goods in both the raw and manufactured states, widespread transportation systems are required. To turn the wheels of industry and provide comfort and convenience in keeping with Canadian standards of living requires a substantial volume of power development of all kinds. At the present time (1949) only about 25 per cent of our known water-power resources have been developed.

Constant growth in all the fields mentioned calls for continuous activity in the construction industry and necessitates expansion of communication facilities. These are all obvious sources of opportunity for people with scientific and technical training.

Scope of Work of Scientists and Engineers

From the occupational point of view, the work of the scientist and that of the engineer are closely related. There is, however, a broad distinction in that the student of the natural sciences is primarily engaged in the search for new knowledge, whereas the engineer devotes himself largely to the application of this knowledge for direct use by the community which he serves. In some branches of scientific work it is almost impossible to define the boundary between research and application, but nevertheless the broad distinction exists.

The four principal fields in natural science are Chemistry, Physics, Geology and Biology. Certain elements of these combine with other things to form the professional field of agricultural science. In the monographs which deal with these five subjects individually, it will readily be seen that they have the common characteristic of being basically concerned with the search for fundamental truths. Scientists are often spoken of as "extending the frontier of theoretical knowledge".

Engineering, on the other hand, has been defined by the Institution of Civil Engineers of Great Britain as "the art whereby the great forces and powers of nature are converted and applied to the use and convenience of man". The craft of the master builder of ancient days came in time to be divided into military engineering and civil engineering. The latter has since expanded into six main branches: Civil, Mechanical, Electrical, Mining, Chemical and Metallurgical, and a number of smaller divisions (numerically), such as Aeronautical, Ceramic, Forest, and Petroleum Engineering.

Personal Qualifications Required

Apart altogether from academic needs, it is necessary to study the general qualifications essential for work in any of the natural sciences or in any branch of engineering. Many authoritative statements have been made in this regard, of which two representative samples are given. In the case of the scientist the following is an extract from the appropriate pamphlet in the "Careers for Men and Women Series" issued by the Ministry of Labour and National Service in Great Britain:

> "The scientist must have not only technical knowledge but also such personal qualities as initiative, resource and self-reliance. Intending entrants should have acquired a habit of hard and purposeful work and logical thought. They should be able to observe and record accurately. Frequently they will have to write reports and to pass information on to other workers, and they must learn to give descriptions and instructions in clear English, whether written or spoken. Imagination, an enquiring mind and patience are essential for research.
>
> "There is room in the profession for persons of all types provided that they have the requisite scientific ability and qualifications. There are, of course, many posts where a capacity for leadership is essential. Much applied research consists of team work which demands a capacity for human contact, but the scientifically gifted but unsocial man will generally find a useful niche."

On the question of essential qualifications for engineers, the Dean of the Faculty of Applied Science and Engineering, University of Toronto, has this to say:

> "For notable success in any branch of engineering, a young man must possess, in a conspicuous degree, the analytical, calculating and planning ability. He should be interested in finding out not only how things work, but more particularly why they work, and still more what might make them work better. Manual dexterity or the "tinkering" ability is not in itself an indication of probable success in the field of professional engineering. Unless an aspirant has a compelling interest in science and its applications and a strong creative instinct backed by an aptitude for quantitative reasoning, his success in engineering will at best be moderate.
>
> "It need scarcely be said that a high and broad intelligence are prerequisites for an exacting profession. Interest in human relationships and the social well-being of one's associates and community must accompany technological competency. Otherwise, the young man will find himself filling the role of a pure technologist, that is, a master of certain techniques, but without broad influence in the world of men and affairs.
>
> "Those personal traits that most contribute to success in these professions are initiative, originality, persistence, self-reliance, integrity, loyalty, co-operative spirit, and leadership. Emotional stability and self-control are, or course, prerequisites for one who must often face very trying and disconcerting situations. Coolness in an emergency is of paramount importance in directing great enterprises."

University Training

The great majority (90 per cent) of those who enter the scientific and engineering professions in Canada do so after securing formal training at a university. It is important therefore to consider the change in methods of study on leaving high school or secondary school and

entering a university or college. It has been said that pupils go to school to be taught but students go to university to learn. In the latter case it is left almost entirely to the student to determine to what extent he will benefit. He must therefore be prepared to organize his own work, which will normally embrace a wide variety of subjects, and so to apply himself that he will secure the maximum benefit.

Scientific and engineering courses are not easy even for good students, and such branches of study tend to become more difficult and more comprehensive from year to year. It is therefore dangerous to assume that the academic path to a degree, even for a student who has enjoyed high standing previously, calls for anything less than the maximum possible degree of concentration.

University Entrance Requirements

The specific entrance requirements for admission to any particular course in a university are set out in detail in the calendar of that university. Before committing himself to any definite action, the prospective student should discuss his problem with one or more guidance counsellors, such as those provided by the engineering and scientific institutes. He should also secure the calendar of at least one suitable university and study it thoroughly.

These calendars contain not only a useful fund of general information regarding the university itself and various forms of student activity, but also set out in detail the actual curriculum of study for each course. In many cases they have quite full notes on the content of each series of lectures or laboratory periods. By studying these it is possible to acquire a better insight into the objectives which the course is designed to attain.

The general trend is toward stiffer entrance requirements in order to ensure better preparation for courses which are themselves more comprehensive. The student who is well prepared for entrance to university may be assumed to have acquired a good general education up to that point. This in turn is quite likely to be apparent in any study of his personal qualifications on graduation.

These will be a most important factor in his professional advancement, and particular mention should be made of the value of being able to speak and write well. Skill in the use of our language is an absolute necessity in scientific and engineering work, and the development of this skill cannot be started too early.

Fees and Living Expenses

The most important item in the cost of a university course is the tuition fee. Not only is the amount substantial, being quite often of the order of \$200 or \$300 per annum, but it customarily must be paid in one lump sum or in two instalments. The actual amount varies, depending on the university attended and the course being taken, but here again definite up-to-date information can always be obtained from the university authorities or from the university calendar in which living expenses and other incidental charges are also dealt with.

A substantial part of the expense of taking a university course can be met by earnings during the long vacations. An increasing number of employers are making it a practice to take a certain number of undergraduates into their employment every summer. This gives the student an insight into the world of work and, in many cases, furnishes experience along definite lines associated with his academic training. In some courses a stated amount of such practical experience is a requirement of the curriculum.

There is a steady increase in the provisions for financial assistance for deserving students. These may involve scholarships or bursaries or financial aid available from various loan funds. This financial aid is administered by universities, professional associations, alumni bodies or other agencies. Authorities at both secondary schools and at the university are well informed regarding the various channels through which aid can be secured by students or prospective students.

Channels of Employment

It is one thing to talk in general terms of opportunities, but quite another matter for the individual student to

locate the actual job which he will be seeking either in his long vacation or on graduation. He will be looking solely for information about specific openings. Such information may reach him in various ways.

The official Government agency for dealing with such problems at the universities is the Executive & Professional Division of the National Employment Service. This division works in co-operation with such employment officials as may exist as part of the university's own organization, and makes available lists of openings, the details of which have been gathered from employers through a comprehensive programme conducted by the Department of Labour. Other employers conduct "recruiting" campaigns at the universities, where students are informed of the nature of the positions available and where they may be interviewed and selected. Still other employers may approach students through members of the university teaching staff who are instructing in some specific subject of interest to the employer.

As the student proceeds through his course, he will have many opportunities to study the employment market in his own particular field of specialization. Discussions with members of the staff are always possible, and there are frequent contacts at meetings and elsewhere with those engaged in various types of work outside the university. In many cases, summer employment as an undergraduate will help to develop an appreciation of the type of career which may be open.

Sources of Employment

Graduates in certain branches of science and engineering will be found in large numbers in industries which are closely related to their specific training. For example, forest scientists and forest engineers are largely concerned with some phase of the forest products industries. The primary source of employment for graduates in mining is the mineral industry.

There is, however, a tendency towards quite widespread distribution in many fields of technical training, and some reference is made to this in the monographs which follow

and which deal with individual types of scientists and engineers.

By way of illustrating this point statistically, the following table has been prepared from data provided by the Dominion Bureau of Statistics' study "Supply and Demand in the Professions in Canada" and the report by the Chemical institute of Canada on "The Economic Status of Chemists and Chemical Engineers".

APPROXIMATE DISTRIBUTION BY SOURCE OF EMPLOYMENT OF GRADUATES IN CERTAIN BRANCHES OF SCIENCE AND ENGINEERING
(by Percentage)

	Chemists	Chemical Engineers	Civil Engineers	Electrical Engineers	Mechanical Engineers
Manufacturing.....	53.8	77.0	13.8	41.4	68.7
Mining............	0.8	1.3	3.0	1.8	2.5
Building Construction.....	—	—	32.8	3.3	4.3
Electric Light & Power............	0.2	—	4.2	21.7	2.2
Transportation & Communication.	0.5	1.0	7.9	20.8	9.0
Trade, Finance & Business.........	3.1	3.0	1.0	2.8	2.6
Professional Services including Teaching	17.9	5.6	10.1	3.0	3.3
Public Authorities Excl. of Education	20.7	9.3	21.5	3.9	5.4
Others.............	3.0	2.8	5.7	1.3	2.0
Total..........	100.0	100.0	100.0	100.0	100.0

Regardless of the source of employment, it must be remembered that the graduate in science or engineering may be called upon to perform any one of a wide range of functions. These have been listed in various ways, but as one illustration the following list will serve:

List of Functions for Scientists and Engineers

1. Research
2. Development
3. Designing, draughting
4. Testing, inspection, laboratory service
5. Installation, erection
6. Production
7. Operation
8. Maintenance
9. Construction
10. Layout and location
11. Administrative and executive
12. Supervision and management
13. Teaching, instruction, extension work, writing
14. Sales and service
15. Consulting
16. Personnel, safety and efficiency
17. Accounting
18. Other—to be described

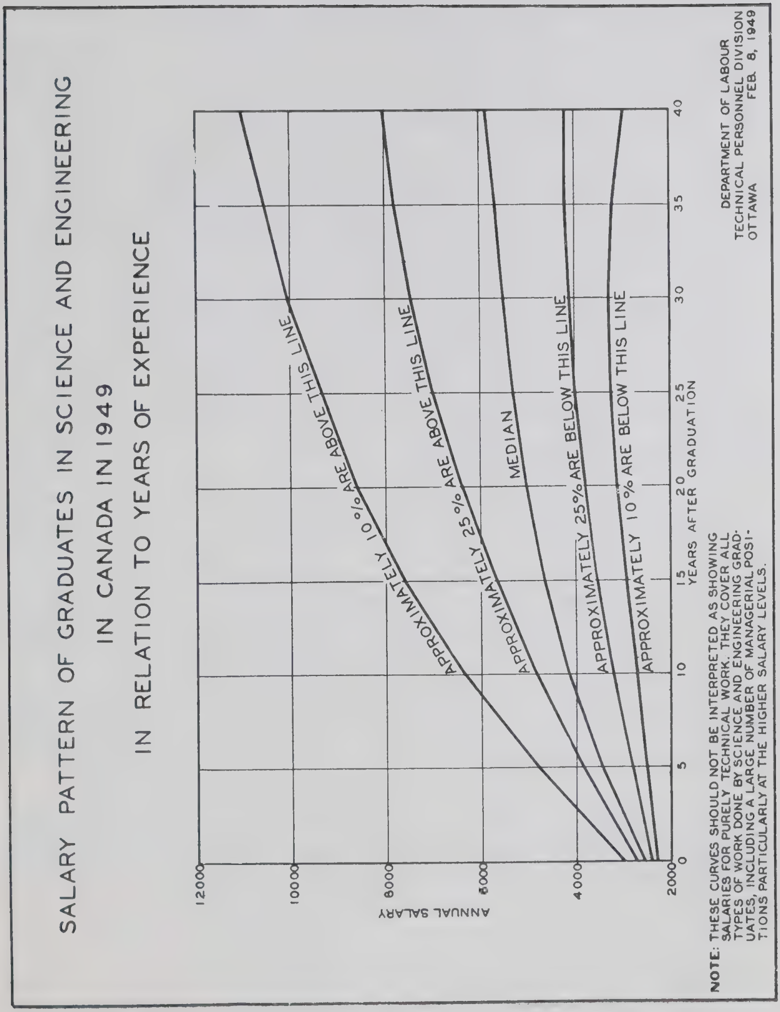
Earnings of Scientists and Engineers

Although various attempts have been made to give a picture of salary scales applying in the case of scientists and engineers in Canada, it is practically impossible to lay down any hard and fast rules as to what salary levels actually exist. The picture is somewhat different in such types of skilled labour as building tradesmen and various categories employed in industrial production. The hourly rate paid to journeymen in the building trades is pretty well established in various communities under agreements between union and management. No such formal scales exist in the case of professional workers in scientific and engineering fields. Some professional bodies are more or less constantly engaged in surveying this matter and attempting to arrive at recommended scales of remuneration. It may be true that such scales are meeting with some degree of favour among employers, but it must be remembered that, in the employment of professional men, there are such things to be considered as widely varying degrees of skill and experience, a number of different functions in which a scientist or engineer may be employed and the difficulty of matching in every case an existing opportunity with the exact type and degree of skill which is required to perform the work involved.

A study of existing salaries does, however, reveal that there are certain basic factors which have wide general application. One of these has to do with the starting salaries offered on graduation. A fairly comprehensive sample of the salaries which it is proposed to offer to graduates of the Class of 1949 shows that less than 10% of the cases fall below $195 per month and also that less than 10% of the cases fall above $240 per month. This suggests a wide degree of uniformity in starting salaries all across the country and over the whole range of branches of science and engineering.

Towards the other end of the scale, the data on salaries paid to graduates in science and engineering is greatly affected, and the averages substantially increased, by the inclusion of large numbers who take on managerial duties in place of their previous technological functions. In very rough terms, it appears that 30 years after graduation,

Figure 1



SALARY PATTERN OF GRADUATES IN SCIENCE AND ENGINEERING
IN CANADA IN 1949
IN RELATION TO YEARS OF EXPERIENCE
ANNUAL SALARY
12000
10000
8000
6000
4000
2000
0
5
10
15
20
25
30
35
40
YEARS AFTER GRADUATION
APPROXIMATELY 10% ARE ABOVE THIS LINE
APPROXIMATELY 25% ARE ABOVE THIS LINE
MEDIAN
APPROXIMATELY 25% ARE BELOW THIS LINE
APPROXIMATELY 10% ARE BELOW THIS LINE
NOTE: THESE CURVES SHOULD NOT BE INTERPRETED AS SHOWING SALARIES FOR PURELY TECHNICAL WORK. THEY COVER ALL TYPES OF WORK DONE BY SCIENCE AND ENGINEERING GRADUATES, INCLUDING A LARGE NUMBER OF MANAGERIAL POSITIONS PARTICULARLY AT THE HIGHER SALARY LEVELS.
DEPARTMENT OF LABOUR
TECHNICAL PERSONNEL DIVISION
OTTAWA
FEB. 8, 1949

probably 10% of the graduates are receiving in excess of $10,000 a year. A very small portion of this top 10% are likely to be employed on technical work. The average of those engaged on purely technical work with over 20 years' experience will be below the median. It is equally probable that 10% with the same range of experience do not receive a salary as high as $3,500 a year. The remaining 80% fall somewhere between these two figures.

The average for the whole group shows a definite tendency to increase with years of experience, and this is no doubt typical of all forms of professional activity. It is a measure of the professional growth and development of the individual scientist or engineer.

This salary pattern is illustrated on the chart at Figure 1, but it is important to remember that all such presentations must be taken with reserve. Any study of actual salaries can apply only at the date at which it is made and gives little indication of what future trends may be.

Sources of Supplementary Information

In the introduction to this book there is reference both to the need for accurate information on careers and to the fact that various professional bodies have co-operated with the Department of Labour in the preparation of this volume. Mention is also made in most of the individual monographs of the professional organization appropriate to the branch of science or engineering dealt with. As an appendix the book contains a list of counsellors who have been appointed by various institutes to give voluntary service to prospective students and others seeking more detailed information.

Every advantage should be taken of these further sources of reliable information. The professional groups concerned wish it to be known that they are prepared to offer all possible assistance along these lines.

SECTION II

CANADIAN UNIVERSITIES GRANTING DEGREES IN NATURAL SCIENCE AND ENGINEERING

Two tables have been prepared (Numbers 1 and 2) listing the various universities giving degrees in scientific and engineering subjects. From these tables it is possible to see at which university instruction is given in any particular branch and at the same time to see in what branches degrees are granted in any particular university.

In the case of degrees in science the universities tabulated may offer either specialized courses or "general science" courses, or both. The difference between these types has to do with the degree of concentration applied to one particular field of natural science. This may be, for example, chemistry or physics or biology or geology. In a limited number of cases, two of these may be combined. Where one of these natural sciences is the major subject of study and the curriculum provides the maximum possible number of hours of lecture and laboratory work, the course is often referred to as an "honour course".

"General science" or "pass science" courses by contrast cover a broader range of subjects of study and in some cases may be both of shorter duration and also based on lower entrance requirements. This type of course is useful from the point of view of general education and may form a sound foundation for further study along more specialized lines. It does not, however, normally lead so readily to any field of employment of a scientific nature.

There is no uniform system followed by all universities in naming the actual degrees awarded. In agriculture, for example, the degree may be that of bachelor of science, or bachelor of science of agriculture. In the case of biology, chemistry, geology, and physics, some universities award degrees in arts and others use the degree bachelor of science. It is important therefore to identify a particular course by the actual content rather than by the label which is used for the degree.

Forestry is shown on both tables because the degree granted in certain universities is in the "science of forestry" and in others the degree is in "forest engineering". The University of British Columbia grants both types of degree.

In the monographs which follow, dealing with specific branches of science and engineering, one or two of the branches of engineering listed in Table No. 2 are not dealt with, namely, agricultural engineering, engineering and business, engineering physics, and mechanical-electrical engineering. Such courses have elements which are common to certain others, and it is felt that the omission of detailed descriptions does not seriously detract from the total treatment. As pointed out in the previous section, fuller details can readily be secured from the calendar of the appropriate university, or from university officials. These may be supplemented by discussion with counsellors who are actually engaged in the work of the profession involved.

TABLE NO. 1
UNIVERSITIES AND COLLEGES GIVING INSTRUCTION LEADING TO DEGREES IN THE NATURAL SCIENCES, AGRICULTURE AND FORESTRY

University	Location	Remarks
Acadia University	Wolfville, N.S.	
Carleton College	Ottawa, Ontario	
Dalhousie University	Halifax, N.S.	
McGill University	Montreal, Que.	A
McMaster University	Hamilton, Ontario	
Mount Allison University	Sackville, N.B.	
Ontario Agricultural College	Guelph, Ontario	A only
Queen's University	Kingston, Ontario	
St. Dunstan's College	Charlottetown, P.E.I.	
St. Francis Xavier University	Antigonish, N.S.	
St. Joseph's University	St Joseph, N.B.	
St. Patrick's College	Ottawa, Ontario	
Sir George Williams College	Montreal, Que.	
University of Alberta	Edmonton, Alberta	A
University of Bishop's College	Lennoxville, Quebec	
University of British Columbia	Vancouver, B.C.	A F
University of Laval	Quebec, Que.	A
University of Manitoba	Winnipeg, Man.	A
University of Montreal	Montreal, Que.	A
University of New Brunswick	Fredericton, N.B.	F
University of Ottawa	Ottawa, Ontario	
University of Saskatchewan	Saskatoon, Sask.	A
University of St. Mary's College	Halifax, N.S.	
University of Toronto	Toronto, Ontario	F
University of Western Ontario	London, Ontario	

A—Degree Course in Agriculture
F—Degree Course in Forestry (Bachelor of Science in Forestry)

With the exception of the Ontario Agricultural College, all the above institutions give instruction in the Natural Sciences, namely Biology, Chemistry, Geology, and Physics. It must be remembered, however, that there are wide variations in three important characteristics of the instruction offered. The first of these is the difference in entrance requirements. The second is the number of years of instruction at university level, and the third is the content along highly specialized lines of the teaching in any one of the four Sciences.

For example, some of the institutions listed admit students to university courses with junior matriculation or equivalent standing, whereas some require senior matriculation or equivalent. In other colleges both "pass" and "honour" courses are given, sometimes with a difference in duration and with different requirements as to academic standards to be maintained during the course.

If the student's objective is to acquire professional standing in one of the Natural Sciences, it is obviously wisest to discuss these matters with the appropriate body which rules on professional standards. In this way information can be obtained as to the assessment of the worth of various courses from the point of view of acquiring professional status in a specialized field. There is no suggestion that the instruction offered in every case is not of distinct value, but the actual amount of work covered in certain courses must be supplemented by further study to meet professional standards in the field of specialization selected.

In selecting the branches of engineering in which to proceed to a degree, students are, at least to some extent, guided by the prospects in the different fields. It is unlikely that large numbers would graduate in any course where the demand was known to be small, and the trend will normally be towards greater enrolment in those courses where there are numerically greater opportunities for employment.

TABLE NO. 2

UNIVERSITIES GIVING DEGREES IN ENGINEERING AND ARCHITECTURE

	ENGINEERING														
	Agriculture	Aeronautical	Ceramic	Chemical	Civil	Electrical	Engineering & Business	Engineering-Physics	Forest	Geological	Mechanical	Mechanical-Electrical	Metallurgical	Mining	Petroleum
University of Alberta				x	x	x		x						x	x
University of British Columbia	x			x	x	x		x	x	x	x		x	x	
Universite Laval				x		x			x	x			x	x	
University of Manitoba					x	x					x				
McGill University				x	x	x		x			x		x	x	
Ecole Polytechnique, Montreal				x	x							x	x	x	
University of New Brunswick					x	x									
Nova Scotia Technical College				x	x	x					x			x	
Queen's University				x	x	x		x		x	x		x	x	
University of Saskatchewan	x		x	x	x	x		x		x	x				
University of Toronto		x	x	x	x	x	x	x		x	x		x	x	

Note 1: Institutions granting degrees in Architecture are listed in the monograph dealing with that profession.

Note 2: The following six institutions in the Maritime Provinces give a three-year course leading to an "Engineering Certificate" which qualifies a student to enter the pre-final year in Engineering at one of the universities granting degrees: Dalhousie University; St. Francis Xavier University; Acadia University; University of St. Mary's College; Mount Allison University; Memorial University College, St. John's, Newfoundland.

Note 3: The first year of a degree course in Engineering is given at McMaster University and the first two years at Ottawa University and at Carleton College, after which the remainder of the course may be taken at a degree-granting institution.

Note 4: Graduates of the Royal Military College are given credit for part of the degree course at universities.

From this point of view the actual distribution of the current year's graduating class (1949) may be of interest. (The figures given are from a report of the Engineering Institute of Canada).

Aeronautical Engineering	55
Agricultural Engineering	51
Ceramic and non-metallic minerals	27
Chemical Engineering	401
Civil Engineering	664
Electrical Engineering	705
Engineering and Business	97
Electro-Mechanics	29
Forest Engineering	22
Geology and Mineralogy Engineering	117
Mechanical Engineering	723
Metallurgical Engineering	82
Mining Engineering	170
Engineering Physics	166
TOTAL	3,309

OPTIONS AND OVERLAPPING COURSES

By reference to the individual monographs which follow, it will be seen that, within any one branch of science or engineering, there are a number of fields of specialization. Preparation for many of these specialized lines of work is provided for in the university course by what are known as options. This narrowing of the field of training, however, does not usually occur in the earlier years of the curriculum, and enrolment as a freshman may often be in a general scientific or engineering course. This leaves open the final choice of both branch and option until one or more years of study have been completed.

Experience has shown that this arrangement serves the useful purpose of allowing the student further time before definitely committing himself to anything more specialized than a general training for science or engineering.

From the point of view of opportunities for getting started on a professional career, it should be remembered that employers do not always make a fine distinction between the various courses of university training. A complete study of the content of all courses offered in universities would undoubtedly reveal that in each case there is much that is closely related to a type of training

that goes under some other name. This can readily be done, at least in a preliminary way, by scrutiny of the calendars issued by the universities themselves.

The task of distinguishing between courses is also complicated by the wide variation in nomenclature adopted by various universities in selecting the actual names of the degrees they award. On one campus for example, it is possible to obtain a B.Sc. degree in chemical engineering, B.Sc. in chemistry (taken in the applied science faculty) or a B.A. in chemistry taken in the arts faculty. On a neighbouring campus the only degrees available are B.A.Sc. in chemical engineering and B.A. in chemistry. In other universities the term B. Engineering is substituted for B.Sc. or B.A.Sc., and there is also a B.Sc. given in "arts and science faculties".

There is, of course, a distinction made at any one university between the purposes of courses in chemical engineering on the one hand and chemistry as a pure science subject on the other. Practice varies from one university to another as to how much common content there is in these various courses, and also as to the extent to which teaching staffs, text books, laboratory courses, etc., may or may not be common to more than one course. In the result, it is not surprising that a number of employers will not hesitate to engage a graduate in chemistry under the title "chemical engineer" or a graduate in applied science under the title "chemist".

Many other examples could be quoted from scientific fields, some of the more obvious ones being forestry and forest engineering, geological engineering (or mining with geology option) and geology, or the group of subjects which may be traced from mathematics through mathematics and physics, physics (electrical), engineering physics to electrical engineering.

Undoubtedly many opportunities to become established in a professional career depend very definitely on the specific type of academic training that the student has undergone. Nevertheless, a substantial number of

graduates will become employed in places where their academic training is assessed on quite general lines.

There is, however, one consideration that applies equally to both groups. The Engineering Institute of Canada made available (Engineering Journal, April 1947) the results of a study made in the United States of "Employer Practice Regarding Engineering Graduates". In this survey employers were asked to arrange, in order of preference, nine items presumably considered when selecting an engineering employee. The order in which employers placed eight of these items (including scholastic record) varied somewhat, but they all agreed that "personality" should head the list.

SECTION III

AGRICULTURAL SCIENTIST

MONOGRAPH 20

Canada's agriculture, through its human and natural resources, has shown remarkable growth during the past sixty-five years. The following comparison of figures for 1881 and for 1941 will indicate in some degree the extent of this growth:

	1881 (millions)	1941 (millions)
Farmed acreage	45.0	175.0
Improved land, acres	22.0	92.0
In grain crops "	15.0	57.0
Wheat crops, "	2.4	28.7
Wheat yield (bus.)	32.0	540.0

A comparison of the years 1881 and 1947 gives further evidence on expansion:

	1881 (millions)	1947 (millions)
Milch cows	1.6	3.7
Other cattle	1.9	6.0
Milk production (gals.)	6,900.0	17,000.0

The average size of the Canadian farm has also expanded. In 1881, the average size was 97.7 acres and by 1941 it was 238.5 acres. The 1946 Prairie Census shows that in Saskatchewan the average size of the farm was 473 acres, whereas in Eastern Canada the average size of farms is about 115 acres. Today, with the use of machines and science, the average Canadian farmer can work about 85 acres of improved land; in 1911, he was able to cultivate only 52 acres.

The current value of farm capital is estimated at almost six billion dollars. The net value of agricultural production is at the $1.5 billion mark.

There is also the agricultural processing industry. About 225 thousand men and women are employed in more than 10 thousand establishments. Slaughtering and meat packing is one of Canada's main industries.

But the proportion of Canadians living in agricultural Canada has decreased markedly. Eighty per cent of Canada's population lived on farms or in small communities in farm districts in 1871. By 1941, the figure was 45 per cent. The actual proportion living on farms was about 27 per cent.

The reduction in the proportion of workers engaged in primary food production, while the output of food is increasing, has been an important factor in establishing Canada as an industrial nation and has been a strong force in advancing the level of living for all of her people. Each advance in the science and technique of agricultural production and marketing, which leads either to a larger output per worker or to a lower cost per unit of product, benefits society by releasing more workers for other employment and by providing food for the consumer at a more reasonable cost. Since levels of living are determined, to a large extent, by the amount of economic goods available per person, increased efficiency in agriculture benefits all people.

Agricultural progress in a developing economy is dependent upon increasing production per worker. New and more profitable uses of manpower, mechanical power, soils, water, plant and animal resources, have to be developed. New and improved market outlets have to be found for farm products. Losses through insects, diseases, and spoilage, have to be reduced. Human nutrition must be improved, and food use for farm products must be extended. And another major task is to make use of the results of scientific research, to introduce them into the economy with a minimum of disturbance, and to pass on the gains to all.

TRENDS

The following lists the broad classification of specializations open to the university-trained agricultural graduate:

1. Inspection and Control
2. Extension and Promotion
3. Teaching

4. Scientific Research
5. Administration
6. Commercial and Industrial Employment
7. Ownership of Business
8. Farming.

The Dominion Department of Agriculture is the largest employer of university-trained agriculturists, with commercial organizations a close second. The provincial departments of agriculture and the universities rank next in order of importance. The Dominion Departments of Trade and Commerce, Labour, and Finance employ agricultural economists. The National Research Council and the Ontario Research Foundation also employ agricultural scientists. The Department of Veterans Affairs employs field men in the administration of the Veterans' Land Act. Last but by no means the least important is farming itself.

Some of the Canadian business organizations that employ graduates in agriculture include:

Advertising Agencies
Agricultural Journals
Banks (Land Departments)
Canneries
Cheese Factories
Chemical Manufacturers
Creameries
Chick Hatcheries
Co-operative Marketing Organizations
Educational Bureaus
Farm Machinery Manufacturers and Distributors
Feed Manufacturers & Distributors
Fertilizer Manufacturers & Distributors
Florists
Fruit Marketing Agencies
Fruit Processors
Grain Elevator Companies
Hail Insurance Companies
Ice Cream Manufacturers
Irrigation Companies
Landscape Gardeners
Life Insurance Companies (Land Depts.)
Livestock Breed Associations
Malting Companies
Meat Packing Companies
Milling Companies
Milk Processors & Distributors
Mortgage and Loan Companies
Mushroom Growers
Newspapers — Daily & Weekly
Nurseries—Trees, Shrubs and Plants
Poultry Marketing Agencies
Railway Companies (Agricultural Depts.)
Spray Material Manufacturers and Distributors
Seed Houses and Organizations
Soybean By-Product Manufacturers
Statistical Services
Sugar Beet Companies
Vegetable Marketing Agencies
Wineries
Wool Marketing Agencies

There is ample evidence of a trend toward wider use of agricultural graduates in industry. Until quite recently commercial and industrial employment ranked after farming, Civil Service and teaching as an occupational outlet for graduates in agriculture. This type of career has now moved up into second place and is already showing signs of crowding government service for the lead. The principal classifications of industrial employment indicated as the choice of the graduating class of 1948 are: handling and processing of foodstuffs, farm equipment, agricultural mechanics, and seed production. Within each of these main classifications there is, of course, a wider variety of specialized lines. Food handling and processing, for example, includes meat packing, milk distribution, preparation of flour and feeds, handling of grain, canning, refrigeration, production of sugar, to mention only a few.

The agricultural colleges and schools listed in Section II require teaching staffs. This is not a large field of prospective employment, as basic staffs are already in existence at those institutions.

A larger prospective field is the teaching of agriculture or general science in secondary schools, including both city and rural high schools.

Scientific research on agricultural problems offers a widely varied field of employment. Although basic staffs have been provided for research units throughout Canada, new problems are constantly arising and specialists in new fields are required.

The number of students graduating in agriculture is increasing. Whereas at one time only slightly more than a hundred students graduated each year, the number receiving degrees in 1948 was nearly 400. There will be three more large classes, about 1,000 in 1949, over 800 in 1950, and over 600 in 1951. These large classes will meet some of the unfilled demand for trained agriculturists. Students should consider this trend carefully.

DUTIES

The duties vary with the nature of the work. We shall refer to our original classification.

1. Inspection and Control

This includes such work as the grading of meat, dairy products, fruit and vegetables, eggs and poultry, seeds, wool, and other agricultural products, and the administration of laws covering the control of plant and animal diseases, and the quality of feeds, fertilizers and spray materials. Agricultural college graduates supervise this work and are assisted in many cases by non-graduate lay inspectors. A large field of work under this heading is the control of contagious diseases of animals, which is supervised by veterinary college graduates, and which is undertaken mainly by the Dominion Department of Agriculture.

2. Extension and Promotion Services

Most of the provinces maintain extension services for the purpose of helping farmers to improve methods, and of encouraging them to take advantage of opportunities for farm improvement and community development. They are located in farming areas, usually one to each county or district; in sparsely settled areas, one to a group of counties; in some highly specialized areas there may be more than one man to a county. These men are assisted by extension specialists, employed by the provincial departments of agriculture or agricultural colleges, who are skilled in particular fields of work such as livestock, fruit, field crops, etc.

The local extension man is usually known as the Agricultural Representative, or District Agriculturist. His task is to make a thorough study of the agricultural possibilities and problems of his area, and to take to the farmers the latest information which may be of benefit to them. This involves continual contact with individuals and organizations in his area. He sends out circular letters, speaks at meetings, organizes campaigns and clubs, and in general is the salesman of scientific agriculture to the farmer.

3. Teaching

This work may call for lecturing and research. The teaching schedule may include degree, diploma and short-course students. Adaptability is an essential requirement for the professor in agriculture at the university.

4. Scientific Research

The work covers the whole field of natural sciences affecting the utilization of plants and animals. It includes the development of new strains and varieties, their nutrition, diseases and pests, methods of production, engineering and processing for human consumption. It comprises the field of economic and social sciences relating to farm management, marketing, community development, and regional, national and international economic policy.

Research work deals not so much with people as it does with materials and ideas.

5. Administration

Administrative positions in agricultural services are filled as a rule by promotion from the ranks of extension, control and research men. A few men go into junior positions in administrative offices soon after graduation, but may rise to the higher positions after they acquire the scientific training and field experience by coming up through the ranks in their various services.

6. Commercial and Industrial Employment

The duties may range from research to promotion. Each specific industry has its own requirements.

QUALIFICATIONS

The qualifications required vary with the nature of the work the individual graduate undertakes and the degree of specialization he desires to pursue.

1. Inspection and Control

For supervising the inspecting of the health of animals and meat grading, the degree of Bachelor of Veterinary Science is necessary. As veterinary inspectors are dealing with livestock, and with farmers and packing house officials who know livestock, a farm background is practically essential for this type of work.

For most other fields of inspection and control, positions are open to agricultural college graduates. Some of the junior inspector classes are open to men who have

had two or three years in college, or in some cases to men who have qualified by experience in the trade concerned. Where inspectors deal with farmers, a farm background is necessary. The trend is to step up the requirements for inspectors, making university graduation a preferable requirement for the position.

2. Extension and Promotion

An extension man must have three main qualifications: he must understand scientific agriculture; he must understand practical farming; and he must be able to get along with people. He has to bring the white-collar specialist and the dirt farmer together, and to get the one to "give out" and the other to "take in".

The requirements for the extension worker are a sound basic knowledge of the scientific principles of the principal types of farming in his area, a practical knowledge of the farmer's problems, and a flair for getting ideas across to people and getting them to take advantage of those ideas. This latter qualification might be described as sales ability. With very few exceptions, a degree of Bachelor of Science in Agriculture or its equivalent is required for appointment as an extension worker. Good hea th and ability to stand travel and long hours are required.

3. Teaching

The student who plans to prepare for university or college teaching finds that he must take post-graduate work, involving usually an additional two years for a Master's degree, and four or five years for a Doctor's degree.

4. Scientific Research

In research work, the pressure of the public upon the worker is not so great as in the case of the inspector, the extension worker, or the teacher. But research requires intensive mental discipline.

A farm background is a requirement for those whose research takes them into the field to deal with cultural methods and crops and livestock. Some of the laboratory

workers do not require a farm background, although it is desirable to have it. A Bachelor's degree in science is essential, and it is preferable to have a Bachelor's degree in Scientific Agriculture. A Master's degree and probably later a Doctor's degree must be taken, providing the worker with further specialization in his chosen field of work, and is usually necessary for those remaining in the field of research.

5. Commercial and Industrial Employment

A good formal education will be an advantage to those entering any line of activity, and the agricultural industries are no exception. Usually there is a probationary period in which the college graduate must learn something of the business "from the ground floor up". Those with a farm background are preferred by most industries.

Post-graduate work is not required as a rule for sales and administrative positions; but for technical positions, business organizations employ men with Master's and Doctor's degree.

TRAINING

A host of specializations constitute the field of agricultural science. Before commencing formal training the young man would be well advised to become familiar with the line of his choice. If the choice is the animal sciences, agronomy, horticulture or any other similar field, summer employment on farms, with agricultural colleges or commercial enterprises is of inestimable value in testing one's choice.

Four-year courses leading to the degree of Bachelor of Science in Agriculture or Bachelor of Scientific Agriculture are given by many Canadian colleges and universities (listed in Section II).

Field employment during vacations is required by nearly all universities and is considered an integral part of the student's training. Most colleges employ students on this basis. The largest single employer of students, however, is the Dominion Department of Agriculture, whose training programme includes the employment of

"Student Assistants" for the summer months. Those whose work is of a sufficiently high calibre are considered for continuous employment with the Department upon graduation. Appointment to all these positions is made by the Civil Service Commission.

ADVANCEMENT

In all agricultural services advancement is based on meritorious service and the assuming of greater responsibilities. Those entering the federal government service usually commence in a probationary training class where they remain for a period of one year. After that time, promotion to the next higher class is automatic if the previous year's service has been satisfactory. Within a class, annual increases in salary are granted subject to meritorious service and greater responsibility.

A great attraction of employment in the government service is its pension plan, which provides employees with a continuous income after retirement. Any person intending to make the public service his life work (based on 35 years of life service) can expect to receive a pension approximately equal to two-thirds of his average salary for the last ten years of employment.

Each of the provinces has its own salary schedule and retirement provisions. These can be obtained by getting in touch with the provincial Civil Service Commission.

Most large industrial and commercial enterprises start their employees at a modest salary while experience and on-the-spot training are received. In a year's time the employee will have demonstrated his ability and aptitude and his salary will be adjusted accordingly. Although no formal plan for advancement is used generally in business, the same general considerations serve as a guide as those used in the federal Civil Service.

Most industries maintain employee benefits such as hospitalization and superannuation, and contribute to these funds on a variety of scales.

ORGANIZATIONS

The Agricultural Institute of Canada, Ottawa.

SUPPLEMENTARY INFORMATION

"Agriculture"—Careers in Public Service. Issued by the Civil Service Commission of Canada.

"Agricultural Industries", "Sciences Relating to Agriculture", "Agriculture and Fur Farming". Part of Canadian Legion Educational Service Booklets series entitled "Let's Consider Jobs". (1944, in French and in English).

"Salary Scales of Professional Agriculturists in Canada (1947)" prepared by the National Committee of the Agricultural Institute of Canada, Confederation Building, Ottawa, Canada.

ARCHITECT

MONOGRAPH 21

This Monograph deals with the architectural profession in relation to building only. Landscape and Naval Architects are thus omitted.

HISTORY AND IMPORTANCE

The most striking evidence we have of the past civilizations of the world lies in the structures which remain to bear witness to the art, skill and integrity of the architects, the "master builders", who created them. It is true that most of what has survived consists of religious, memorial, and administrative buildings, but excavations have revealed, especially in the case of the Roman empire, that domestic architecture was equally well-planned and executed.

In the Dark Ages the Church kept the art alive, and the Middle Ages have left a legacy of wonderfully beautiful cathedrals and churches to contrast with the highly functional fortresses which here and there remain as evidence of another major activity of the architects of that period. The Renaissance gave a new impetus to domestic architecture, as well as stimulating radical changes in the design of public buildings. As more stable and effective government gave greater security of life and property, and new wealth was created, an improved standard of domestic life gave opportunities for the designing of private residences which combined beauty with the maximum amount of convenience and comfort then obtainable.

Industrial advances in the production of materials such as glass, iron, steel, ceramics and plastics, and of mechanical aids to building, have had a marked influence on architectural practice, and improved methods of water supply, sanitation, insulation, heating, cooling, fireproofing, lighting and communications have all called for new applications of the architect's skill and knowledge. Domestic, industrial, commercial and public

construction have undergone changes which reveal how well the profession has made use of modern developments.

Man's primary physical need for shelter may now be satisfied with an accompaniment of comfort, safety, convenience and beauty. It is to the architect that we owe this, and it will be to his constant touch with new developments that the future will owe structures beyond the imagination of the present.

DUTIES

The functions of the architect are the design of and the direction of the construction of structures. He may act similarly in connection with the alteration and extension of existing buildings. He combines the duties of an artist, an engineer and a cost estimator, with those of a businessman and an inspector of workmanship and of materials in construction. He must also see that construction complies with legislation governing such operations.

The architect obtains his client's requirements and examines the site of a projected building to ascertain its possibilities and peculiarities. He then designs the building and submits sketches to his client. After these are approved working drawings are prepared. These are the drawings from which the building is built, and include the ground plan, floor plans, elevations, sections, scale details, etc. He writes the specifications describing the construction in terms of material and workmanship. The architect then obtains and advises on the selection of suitable contractors, supervises the actual construction after supplying the contractor with all necessary drawings and instructions, acts as liaison between the owner and the contractor, and certifies the quality, quantity and value of work done by the latter from time to time.

QUALIFICATIONS

It is extremely important for anyone considering entering the profession to satisfy himself that he has the natural aptitudes for the work. Primary requisites are a creative and imaginative mind, courage to be original, aesthetic appreciation and the power to visualize. Com-

bined with these must be an aptitude for the basic subjects—mathematics, science and language—necessary in the study and conduct of the profession. Since the architect must be also a businessman, and deal with people, materials and money, he must be practical, scientific, pleasant, tactful, forceful and firm. Architects are expected to be leaders, not of the building industry alone but in public affairs as well. In addition to his technical knowledge and skill he must have an understanding of political economy, sociology and history.

Generally speaking, educational prerequisites for professional courses in architecture include senior matriculation standing (some schools require higher than pass standing in certain subjects). Courses of study in the fine arts and in their history will be an advantage in later studies. Experience in construction work and in architectural draughting will be helpful. Enquiry should be made of the university at which it is desired to train, in order that any changes in entrance requirements may be ascertained.

TRAINING

(a) Academic :

Courses for the degree of Bachelor of Architecture are given as follows:

(1) Schools recognized by the Royal Institute of British Architects

McGill University: 5 years; practical work in each summer vacation. Prerequisite Senior Matriculation with adequate mathematics.

School of Architecture, University of Toronto: Admission Ontario Grade XIII in certain subjects, 5-year course plus 12 months practical experience.

University of Manitoba: 5-year course, preceded by 1 year in Arts or Science. Senior Matriculation required (Manitoba gives a pre-architectural year for Junior Matriculants).

(2) Other Schools

Ecole des Beaux-Arts, Montreal: 5-year course plus a preparatory year; instruction in French only. This

course is recognized by the provincial professional associations of architects as having equal standing with those of the four universities.

University of British Columbia: 5-year course, preceded by one year Arts or Science. Admission requires 60% standing in Mathematics and Science, Senior Matriculation.

Counsellors should verify the requirements of each of these courses, which are likely to change from year to year.

(b) On the Job (as a registered Student)

A student, duly registered with the provincial Association, may work in an architect's office as a draughtsman, and take evening classes or correspondence school study to prepare for the Association's examinations, which, if passed, give professional standing. This method may take up to ten years. In British Columbia four years is the minimum, and intermediate and final examinations (as in the case of Chartered Accountants) must be passed. Needless to say, this will be a long and difficult procedure, and it cannot be hoped to reach the same standard of education and training as in a course at a school of architecture.

ENTERING THE PROFESSION

Contacts established during the university course may serve to place graduates. Initial employment may be in a junior capacity such as draughtsman.

Those training as working students under a registered architect will already be placed.

Admission to some provincial Associations may not be applied for until the candidate has had two years' experience following graduation.

ADVANCEMENT

Advancement may be from draughtsman to more important work, eventually to a partnership or to practice on own account. As in other "own account" professions, economic advancement will depend largely on connections, ability, business conditions, personality, location and opportunity.

RELATED OCCUPATIONS

Civil engineering and surveying are closely related to some phases of architecture. Town planning, industrial and commercial design, interior decorating, teaching of architectural draughting and design, stage setting design, building contracting, and quantity surveying are occupations touching on architectural fields.

ADVANTAGES

The individual and creative nature of the work, and the opportunity for self-expression, together with the satisfaction of seeing one's ideas taking concrete form, make this one of the most engrossing occupations. The contacts with varied types of person add to its interest, and the architect's social status is definitely established. Legislation and professional organizations serve to prevent unqualified competition from affecting his economic status.

DISADVANTAGES

The long preparation and its attendant expense, combined with relatively low income for some years after graduation, make this profession, in common with others equally respected, unattractive to those who desire or need immediate financial rewards.

Unfortunately, also, the irregular progress of the construction industry, associated with the ups and downs of the general economic situation, has a marked effect on the activities and incomes of architects. Should more stable conditions in construction be contrived, this effect will be minimized.

EARNINGS

A student who enters the profession through "training on the job", may expect a nominal salary of $10 or $15 a week to start with, and may rise to $50 to $75 a week. Graduates of professional courses at a university may start at $20 to $35 a week, and rise as employees to a rate of $60 to $100. The average salary of employed qualified architects was, in 1941, $2250. It is probably larger now, following the trend of such related professions as En-

gineering, where a salary of $3000 for junior positions has been aimed at in a schedule prepared by one provincial association.

Architects on their own account may, in normal times, receive a net income of $5000 or even $10,000. This is derived from a percentage fee on buildings designed and supervised, ranging from 6 per cent for larger contracts to 10 per cent for small.

Out of these fees the architect must pay all his expenses, including the fees of consulting engineers.

In goverment and municipal employment, architects, who must be experienced, can expect from $3000 to $6000 a year.

ORGANIZATIONS

Royal Architectural Institute of Canada (composed of members of all Provincial Associations)
Architectural Institute of British Columbia
Alberta Association of Architects
Saskatchewan Association of Architects
Manitoba Associations of Architects
Ontario Association of Architects
Province of Quebec Association of Architects
Architects Association of New Brunswick
Nova Scotia Association of Architects

The Royal Architectural Institute of Canada is allied with the Royal Institute of British Architects.

TRENDS

Number in the Profession

The 1941 Census listed about 1,300 architects. The number registered with provincial Associations was 960 in 1944, and 1070 in 1947.

Age Distribution

About 30 per cent of architects in Canada in 1941 were over 55 years of age, and only 489 were under 45. In 1947 no fewer than 40 per cent were in the age group 57-and-over, and fewer than 20 per cent were under 37 years of age.

Sex Distribution

Of the 1,300 above mentioned, only twenty were women.

Comparison With Related Profession

The number of architects quoted compares with about 6,000 in the nearest related profession, that of "Civil Engineer".

Geographical Distribution

Of about 1,200 architects registered in 1948 with the various provincial associations, almost 80 per cent were in Ontario and Quebec. Most were located in cities of over 30,000 population.

Industrial Distribution

In 1941, half of the number of architects were in private practice, one-fourth employed in the building and construction industry, one-tenth in public works departments of governments and municipalities, the remainder in primary and secondary manufacturing industries.

Growth

The number in this profession was virtually unchanged in the decade 1931-41, and showed, in the latter year, an increase of 130 only over the 1921 total. This increase, amounting to just over 11 per cent, compares with 31 per cent for the population as a whole for the twenty years, and 18 per cent in the decade 1921-31. It reflects the instability of economic conditions between the wars, and their great deterioration in the 1930's resulting in the lack of permanent building, and indeed the serious deferment of most necessary construction.

The degree of unemployment in the profession may be very severe in times of construction lags, and, on the other hand, a recovery of construction activity may provide far more work than can be handled. Since 50 per

cent of architects are in private practice, no data are available on the degree to which these extremes affect the profession.

Present Demand and Supply in this Profession

Apart from private practice, there is at present a marked shortage of architects for salaried employment. In spite of this demand, the proportion of architects recorded by the Bureau of Technical Personnel as entering new employment during the fiscal year 1946-47 was only 1.6 per cent, or 87, out of a total of 5437 professional placements. This compares with 16 per cent in civil engineering, 15.7 in mechanical engineering, and 12.8 in electrical engineering.

In the 25-year period 1921-45 total graduates in architecture numbered 544, an average of about 22 per year. In addition to these, however, there was a very small (possibly 30) supply of registered students who did not attend university, but wrote the Provincial Association examinations. Enrolment in the four schools in 1944 totalled 118; in the academic year 1947-48, there were 52 students in the final year, 90 in the 4th year, 222 in the 3rd year, 246 in the 2nd year, 235 in the first year, and 11 preparatory, in the five schools. A very large proportion of these students were veterans. The current trend is therefore towards an increased number of graduates, apart from student draughtsmen whose number would be limited by the number of practising architects prepared to accept them for training. 1945 graduates numbered only 17.

Present conditions are distinctly abnormal. What they will be when the two large veteran classes graduate depends on unpredictable factors outlined later in this monograph.

Future Prospects

The short-term outlook is excellent for qualified architects, and their student draughtsmen will, no doubt, be acquiring unusually extensive experience.

Long-term prospects are very largely dependent on the factors outlined below.

Qualifying Factors Affecting the Future of the Profession

(a) Major economic changes, such as a falling-off in export trade, or its expansion, will govern all industrial construction and the more elaborate private housing.

(b) Public construction of bridges, canals, such major undertakings as the St. Lawrence Seaway, power plants, large government buildings, or new parks, and town-planning will create a larger field for the architect.

(c) Delays in construction projects caused by material and labour shortages have already occurred, and high material prices, in part caused by export demand, are now a factor in slowing up industrial as well as domestic building plans.

(d) Since this is largely an urban profession, an increase in urbanization will act favourably. On the other hand, greater prosperity and a desire for improved buildings may lead to some expansion in such provinces as Saskatchewan, where architects are very few (1 to 132,453 population) outside of the cities.

(e) An era of over-expansion, excessive credit, and inflation, such as the first decade following World War I, would be likely to have the same effect on the profession as did that one.

(f) Technological changes in materials and the function of buildings are likely to give greater opportunities to the progressive architect, while possibly affecting the more conservative adversely. Some architects have their own preference in styles, and the adaptation of old styles to new conditions may be difficult.

(g) Immigration, if in quantity, would have a delayed effect of a favourable nature.

Conclusion

The short-term outlook is good in this profession; unpredictable factors govern what comes later. It is clear that the profession has not been over-crowded, and that while there may not be any future surplus of persons, the annual accessions to its ranks from 1950 on will be much more numerous than the average in the past quarter-century.

REFERENCES

Additional information may be found in:

Vocational Guidance Centre, University of Toronto, *Architect* (1948 Edition).

Royal Architectural Institute of Canada, *Architecture as a Vocation.*

Lescaze, *On Being an Architect.*

BIOLOGIST

MONOGRAPH 22

Biology is the science of life or of living things. Among scientists and engineers biologists form a comparatively small group, but this should not be taken to mean this field is in any way unimportant. On the contrary, the study of plants and animals is at the very root of a number of types of professional work.

Its application lies in four main areas, the first of which is, of course, biology itself. The principal functions under this heading are teaching and research, which must be linked together because teaching, to be useful, must constantly be tapping new fields of knowledge.

Another obvious application of biology is to be found in the study and practice of medicine.

A third group of opportunities for biological scientists is to be found in the great primary industries, agriculture, forestry, and fisheries, which themselves deal entirely with living things. These involve problems of breeding, nutrition, health and disease very much like those which face the medical man in his work among human beings.

The importance of the fishing industry in the Canadian economy has, especially, led to increasing opportunities in government service in the field of fisheries biology, involving a very wide range of activities. The field covers fresh-water as well as salt-water fish.

In the manufacturing industry there is further scope for the biologist in the preparation of drugs and disinfectants, insecticides and weed controlling agents, and in all processes involving fermentation, to mention only a few fields.

Biology as a science is often divided into two great branches, namely, zoology (having to do with animals) and botany (the science of plants). Each of these two branches covers such a tremendous field of study that they are usually treated as separate subjects. Such further divisions as bacteriology, entomology, and physiology claim their share of students.

Regardless of the specialized course of study or type of career selected, however, biological science is always concerned with certain definite aspects of animal or plant life. It begins with morphology, the study of the actual form of the living animal or plant. In this way are set up the systems of classification of living things without which orderly study would be impossible.

This is followed by the examination of the normal functions of the particular form of life being investigated, its origin, habits, and distribution. From this point the study may branch out into a more specialized treatment of nutrition, disease, breeding, or, in the case of harmful forms of life, the most adequate means of control.

It will be seen from the above that the type of employment available to those who take up biology as a career is pretty definitely determined in advance. There will be posts in government departments or other public agencies, particularly those concerned with natural resources. University teaching appointments will be available for a certain number of graduates who will normally combine teaching duties with a more or less constant programme of research either in the laboratory, or in the field, or both. In the case of opportunities in industry there will quite likely be a trend towards a wider appreciation of the contribution that the biologist can make in many industrial processes.

When this profession is being considered by anyone who has yet to embark on university training, it is important to emphasize that good biological work requires sound fundamental knowledge of chemistry and physics. An interest in, and an aptitude for, the study of various forms of life is an obvious requirement.

CHEMIST

MONOGRAPH 23

The profession of chemistry is probably the most diversified of occupations. The dictionary definition of chemistry is "that branch of science which deals with the several elementary substances, or forms of matter, of which all bodies are composed, the laws that regulate the combination of these elements in the formation of compound bodies, and the phenomena that accompany their exposure to diverse physical conditions". It will be noted from this carefully worded definition that all material things are within the field of chemistry.

FIELD OF CHEMISTRY

It is natural that such a broad field should be divided for the purpose of specialization. The main divisions are organic chemistry, inorganic chemistry, biochemistry and physical chemistry, and each of these has fairly well recognized subdivisions.

Organic Chemistry is applied to carbon compounds and includes the following subdivisions: proteins, synthetic resins and plastics, petroleum and fuels, resins, gums and varnishes, textiles, dyes, wood, paper and pulp, rubber and related synthetics, fuels and carbonization products, explosives, oils, fats, waxes and soaps, alcohols and their derivatives, solvents, cellulose, sugars and starches, organic acids, leather and protective coatings (paints, etc.)

Inorganic Chemistry is applied to non-carbon compounds and has the following subdivisions: alkalis, nitrogen, sulphur and its compounds, industrial gases (ammonia, oxygen, refrigerants), inorganic acids, (sulphuric, hydrochloric, nitric), industrial water chemistry, metals and their compounds, inert gases (helium, neon, argon), composition building materials, halogens (fluorine, chlorine, bromine, iodine).

Biochemistry deals with living organisms and is applied to: food (composition and treatment), agriculture (soils,

disinfectants, insecticides, fertilizers), pharmaceuticals (drugs, perfumes, etc.), municipal water, fermentation, nutrition (food requirements), and physiology.

Physical Chemistry is concerned with the natural laws that govern chemical transformation. It is applicable to any material and includes the following subdivisions: reaction kinetics, electrochemistry, photochemistry, colloid and surface chemistry, atomic and molecular structure, corrosion chemistry, and thermodynamics.

Within each of the branches of chemistry listed above, there are different kinds of work for the chemist to do. The principal functional specializations are research and the control of production processes. There are, however, many others in which the chemist may specialize, such as analysis, teaching, patents, sales and technical service, consultation and administration.

EDUCATIONAL QUALIFICATIONS

A chemist today must have at least a B.A. or B.Sc. degree with a "major" in chemistry. A post-graduate degree (M.A., M.Sc., Ph.D.) is frequently required for positions in research and teaching and for the better positions in industry.

After obtaining his bachelor's degree and thereby entering the profession, the student may begin its practice or may choose to take further university training leading to a Master's or Doctor's degree. It is at this point in his career that he encounters original research, and must choose a comparatively narrow field for specialization. In fact, the most important research problem of his career is probably the selection of his specialty.

CONDITIONS OF WORK

Some generalization is possible in regard to the conditions under which the chemist works. Few set up private practices as do medical doctors, lawyers or architects. Most chemists work for large organizations such as manufacturing companies, government laboratories

or educational institutions. These are almost always located in or near large centres of population, so that the typical chemist is a salaried man living in an urban community. The remuneration received is about the same as that of other branches of science and engineering at the same educational and experience levels. Because he works for a large organization, the typical chemist has a high degree of financial security but, on the other hand, he has less opportunity to obtain the high incomes that are received by successful men in private business. It can be said, therefore, that in general the chemist has a secure environment in which to conduct his work, and if the work itself is his chief interest this condition will be satisfactory. On the other hand, if the student is primarily interested in independence and financial gain, there are probably other occupations that will suit him better.

WOMEN IN THE OCCUPATION

Discounting the number of women employed as pharmacists, the number of female chemists gainfully occupied in 1941 was only about 180. Out of this number, the majority (135) were employed in the service industries and the remainder in manufacturing. Over 40 per cent (74) of the women chemists were employed in "Health" work; only three were shown under "Education"; 19 were in the employ of the Federal Government. As the foregoing indicates, the medical field offers, perhaps, the most favourable area of employment for female chemists. There are opportunities in this field for women analysts, technicians and research assistants. A promising field for female chemists with library training or experience is in chemical library work. There is the possibility of more women entering the manufacturing field as analysts and research workers. Precedent for this was established in the war just past. The fact that it is becoming physically easier to operate large-scale chemical equipment will also open up the field to women. The trend, however, towards the greater employment of women in manufacturing occupations will probably develop slowly.

AGE DISTRIBUTION

Only 8 per cent of the total number of chemists and metallurgists were in the age group 55 and over in 1941. This compared with an average of 13 per cent of all professions. Nearly 60 per cent fell in the age group 18-34. It would thus appear that the number of openings occasioned through retirement or death will be slight.

Statistics issued by the Bureau of Technical Personnel in January 1946, bear out these percentages for chemists. The contrast between chemists and engineers, so far as age is concerned, is quite striking. Using the B.T.P. figures, 23 per cent of all engineers were in the age group 56 and over, as compared with 7 per cent (plus) for chemists; in the age group 16-35, 37 per cent as against 60 per cent for chemists. It can be concluded, therefore, that openings for chemists because of retirement or mortality factors will be considerably fewer than for engineers as a group.

GROWTH

The number of chemists and metallurgists (including employee-pharmacists) jumped from 3,318 in 1931 to 8,202 in 1941, an increase of 147 per cent. Leaving out the pharmacist group, the increase arrived at is approximately 130 per cent. It would appear that between 1941 and 1945 there was a further increase of 35 per cent. The slower rate of increase in this latter period may be accounted for by a decline in the number of graduates during the war years.

The marked expansion in numbers in the decade 1931-41 was largely due to the greater utilization of the chemist's skills in manufacturing.

The discovery of new chemical products, processes and methods makes for a greater demand for chemists and other technical personnel. The extent to which industry is willing and economically able to utilize technological innovations will determine the degree of demand occasioned by this factor.

Although the demand for chemists is not as strong as it was in the war years, it still remains firm. No appre-

ciable difficulty was encouraged in the placing of graduate chemists in 1947, and placement of 1948 graduates has been very satisfactory. From its survey of employers, the Bureau of Technical Personnel estimated that there was a potential demand for 1,100 chemists in the five-year period 1947-51. Past trends and the greater emphasis given to scientific endeavour today would indicate continuing expansion in the field of chemistry. Chemistry is a dynamic and not a static field, one in which new discoveries tend to give rise to new employment opportunities.

ORGANIZATIONS

Chemical Institute of Canada
18 Rideau Street, Ottawa.

This Institute is the national organization for chemists and consists of 26 local sections. Student chapters are also maintained by the Institute at most Canadian universities. Membership in this organization offers a good means of keeping in touch with new developments in the field of chemistry.

REFERENCES

The Chemical Institute of Canada: *The Professions of Chemistry and Chemical Engineering in Canada,* 1948, by Dr. L. H. Cragg, Department of Chemistry, McMaster University. This fine guidance booklet is of great value to students interested in these professions and to all vocational guidance counsellors.

The Chemical Institute of Canada: *The Economic Status of Chemists and Chemical Engineers in Canada, 1948.*

Publication — *The Canadian Chemistry and Process Industries*—March, 1948.

GEOLOGIST

MONOGRAPH 24

Geology is one of the natural sciences and may be briefly defined as dealing with the constitution and structure of the earth. Canadian geologists are concerned primarily with rock formations and mineral deposits. Systematic examination of the country started with the organization of the Geological Survey of Canada in 1842. It has been continued ever since by that organization of the Federal Government, complemented by provincial Geological Surveys or Departments of Mines, and by private individuals and corporations. Obviously it is of prime importance to the people of Canada to find out what the country contains. Much of the pioneering work in this field is done by geologists and they are concerned with the progressive development of the mineral resources of the country at every stage.

DUTIES

The field of the geologist is a broad one, and he is called on to do many different types of work. Field work generally involves mapping. This ranges from rough reconnaissance surveys to very detailed mapping of mining properties. The strictly geological part of this work begins with mapping of bed-rock and soils, just as the topographer maps roads, buildings, and other surface features. The different kinds of minerals and rocks must be distinguished by study of their various chemical and physical properties. The structural and age relations of rock bodies, and such other features as will contribute toward an understanding of the origin and history of the outer part of the earth, must be noted and recorded. Field work is usually supplemented by laboratory studies of minerals and rocks.

Most geologists are concerned directly or indirectly with the finding or exploitation of deposits of the various metals, and of coal, oil, or other mineral raw materials needed by mankind. Some deal with soils, water supply,

control of streams, selections of sites for dams, reservoirs, buildings, etc.

Results of field and laboratory studies are ordinarily presented on maps and in written reports. Those prepared under government auspices are printed and made available to the public.

Most of the positions available in Canada are suitable only for men, but a few women are employed in museums and laboratories. To do effective geological work it is necessary to have an elementary knowledge of physics and chemistry, and a sound knowledge of minerals, rocks, and rock structures. Training in various methods of surveying and mapping is necessary and some knowledge of additional subjects, such as mining and geophysics, may be desirable, depending on the particular field of endeavour.

PERSONAL QUALIFICATIONS

Those who have a good physique and who love the out-of-doors, travel, and adventure, will find geological field work a natural outlet for their energies. For those who prefer more centralized and detailed work there are many jobs in mines and a few in commercial laboratories, in schools, or in universities, which would be to their liking. Success in any of these departments will depend on the intelligence, diligence, initiative, and judgment of the individual.

TRAINING

Training for geological work is obtained at a university, where a student may register in an arts, science or engineering faculty and proceed to a Bachelor's degree. Advanced training is normally required, and the Ph.D. degree is usually obtained after three or four years of post-graduate study. The Ph.D. degree is required for geologists entering the Geological Survey of Canada. Summer jobs in the field are important in the training of the student geologist. A number of student assistants are employed each summer by the Dominion and Provincial Geological Surveys.

The work of the geologist is closely related to that of the prospector on the one hand and the mining engineer on the other. He occupies a very important position in this regard, as he furnishes a scientific interpretation of the prospector's discovery and provides the geological data which enable the mining engineer to develop a mineral deposit into a mine.

Steady work is normally available for adequately trained geologists, either working for government organizations or privately employed. Government work, and work with the larger mining companies, is the most dependable. Work with smaller mining companies fluctuates with depressions and booms. Annual holidays with pay are normally provided.

Geological field work is one of the healthiest types of activity, usually entailing outdoor employment for most of the summer months.

PRESENT STATUS AND TRENDS

Rapid expansion of the mining industry in Canada has demonstrated the widespread occurrence and great value of our mineral resources, yet only about 11 per cent of Canada has been investigated by geologists adequately as a basis for intelligent prospecting.

The enormous amount of preliminary work required in the little-known parts of Canada, together with a comparable amount of detailed geological work necessary to develop and exploit valuable deposits when found, will require all the well trained geologists we can produce for many years ahead.

ORGANIZATIONS

The Canadian Institute of Mining and Metallurgy,
906 Drummond Building, Montreal, Quebec.

PHYSICIST

MONOGRAPH 25

The study of Physics is distinguished from that of other branches of knowledge both by its method and its content. While it attempts to co-ordinate what we can discover about the properties of material things, and even (to a limited extent) to utilize the co-ordinated knowledge to the advantage (or disadvantage) of mankind, it is not to be confused with engineering. It is one of the primary requisites of a physicist that he be capable of a certain degree of abstraction in his mental habits; that he rely on broad principles rather than on codified (hand-book) data.

Physicists have, in emergencies, performed with remarkable success duties which would ordinarily fall upon engineers. However, they would not usually be regarded as experts in that field, since they lack the economic principles which constitute the main discipline of engineers. Yet it would often be hard to say where physics ends and engineering begins. A competent experimental physicist should possess some engineering skills, and an engineer who knows (and appreciates) some physics is — every physicist will admit — a better engineer.

Perhaps it is the emphasis on mathematical methods which most clearly sets apart physics from other sciences. An experimentalist, while not making a great deal of use of formal mathematics, thinks in terms of quantitative relationships, and his analyses, though verbal, are none the less mathematical. Yet it would be an error to think of a physicist as an applied mathematician. The laboratory is the ultimate, and only, authority recognized by a physicist. Applied mathematicians make use of physical concepts but their almost complete disregard of the verdict passed by the laboratory on their conclusions sets them quite apart from physicists, however "theoretical" the latter may be.

TRAINING OF A PHYSICIST

The first years of a physicist's training are devoted largely to the accumulation of physical facts. The broad principles of physics cannot be made intelligible until a sufficient number of examples are available to illustrate them—start inductively, not deductively. Young men have an enormous capacity for absorbing information (if it is to their liking), and all the major Canadian universities offer good facilities for filling them up. After two years of university training (in which a fair emphasis is rightly placed on mathematics), the student of physics should begin to perceive, in outline at least, some of the fundamental principles of his subject. These should become part of his actual mental habits before his four-year undergraduate course is completed.

If the student is fortunate enough to be able to continue his work for a post-graduate degree (and there are an increasing number of opportunities for him to do this), his general training can continue while he carries on research work along some special line. The particular research problem which he may tackle is of little importance. He is still at the learning stage, but learning no longer from lectures and demonstrations alone.

The enormous accumulation of physical knowledge makes it nowadays completely impossible for any one man to survey the whole, even in a very superficial way. As in many other departments of knowledge, specialization of some kind is eventually necessary. One should, however, never lose sight of the fact that a thorough basic training makes it relatively easy to change from one special branch of physics to any other—the same fundamental principles dominate all branches.

THE BRANCHES OF PHYSICS

The subdivision, familiar to every schoolboy, of physics into heat, light, sound, etc., is made largely for pedagogical convenience. We may take these "subjects" for granted, and simply list a few of the main lines of research which are being prosecuted most actively at the present time. The list will give a rough idea of some of the topics

in which instruction and research experience can be obtained at a Canadian university.

Spectroscopy—atomic and molecular
Quantum Mechanics
Theory of the Solid State
Nuclear Structure
X-Ray Spectroscopy and Applications
Low Temperature Physics
High Pressure Physics

These are just a small selection from the total which includes innumerable items of so-called "general physics".

SPECIALIZED BRANCHES

The practical physicist and the engineer are fused together by a training in engineering physics, now available in several Canadian universities. The course, which appears to satisfy a definite demand, turns out engineers rather than physicists, but engineers with a flair for thinking akin to that of physicists. On the whole, the plan has been successful, and many students contemplating the study of physics might well compare and contrast "straight" physics with engineering physics. Some branches of physics (for example, aerodynamics or electronics) might appeal to the type of student who is attracted to engineering physics.

Of the many specialized activities into which a man trained in physics might enter, we might mention the field of biophysics, in which he places the scientific method at the service of biological science. The latter is essentially a qualitative and descriptive study, and although some finesse is required to bring about a rapprochement of physicists and biologists, the results achieved so far are very promising.

Meteorology is a subject (a branch of physics, in fact) which a physicist might well cultivate. It is perhaps in a research capacity that he could here be employed to advantage, and the tendency to make him a forecaster of

weather is deprecated by some members of the profession. However, meteorology is a field in which increasing opportunities for physicists are becoming evident.

Closely related is another special branch of physics: geophysics. If the physicist resists the temptation to become a prospector, he can work in seismology or study the radioactivity of rocks, the structure and movements of the earth, — in short be a geophysicist. It is a field in which opportunities will increase in the future. By contrast, astrophysics might attract a physicist to a university or observatory where he could reasonably expect his work to be of no military or economic value (yet).

AERONAUTICAL ENGINEER

MONOGRAPH 26

Aeronautical engineering, originally a minor branch of mechanical engineering, has in recent years come to be considered rather as a specialized field of engineering.

A person who is well trained in fundamental principles in one of the broader fields of engineering or science is qualified not only for entry into aeronautical engineering in its narrow sense but into the other engineering fields in the aircraft industry; viz. civil, electrical, mechanical, metallurgical, etc.

It is difficult to estimate the future need for aeronautical engineers in Canada. Much depends on the programmes planned by the major aircraft producers, some of whom are pursuing an active policy. The National Research Council employs engineers for work in such special fields as Aerodynamics, Flight Research, Structures, Hydraulics, Gas Turbines, Gas Dynamics and Supersonic Work. There is always the possibility of British interests expanding their Canadian activities.

In Canada the field of opportunity for aeronautical engineers in general has been very limited, although during the second world war, and the period which preceded it, there was a considerable broadening of scope. Since the war commercial requirements have not replaced the wartime military requirements, even though there has been some effort on the part of the Dominion Government to keep the aircraft industry alive and maintain at least a nucleus of trained personnel about which a substantial industry could again be built in case of need.

The value of a degree in aeronautical engineering appears to have received undue emphasis in the minds of some prospective aviation enthusiasts. Training in this field is advisable only after the advantages of a good grounding in the broader fields of engineering or science have been stressed.

THE FIELD OF AERONAUTICAL ENGINEERS

Apart from the aircraft industry the other potential fields of employment for aeronautical engineers in Canada are as follows:

(a) Educational institutions
(b) Research establishments
(c) Airline operators
(d) Feederline operators
(e) Department of Transport
(f) Department of National Defence (Air Force)
(g) Fleet Air Arm

Item (a) is practically a closed field since there is only one university having an aeronautical engineering department and since the number of students is bound to decrease due to the reduction in demand for aeronautical engineering graduates.

Field (b) may continue to absorb a few engineers but is generally less remunerative than other fields.

Field (c) may offer a limited number of jobs in view of some contemplated route expansions and acquisition of new equipment.

Fields (d), (e), (f) and (g) cannot be considered as promising under present circumstances. The outlook could alter very quickly.

FIELDS OF SPECIALIZATION

Having outlined the serious limitations of opportunity for aeronautical engineering in Canada, it is also fair to point out the scope which this branch of the profession generally offers for the exercising of engineering ingenuity. While it is a specialized branch, it has at the same time many ramifications which are interlaced with other branches of engineering, as for example:

Aero and Hydrodynamics
Structural Design
Stress Analysis
Vibration
Power Plants

Propellers
Electrical: Controls, Instruments, Power Transmission, Illumination, Heating.
Radio and Radar
Thermodynamics
Metallurgy
Hydraulic Servos
Mechanical Controls
Air Conditioning
De-icing and Anti-icing
Fire Protection

Engineers with a broad engineering background are capable of transferring from electrical, civil, mechanical, metallurgical engineering, etc., to aeronautical engineering and vice versa.

DUTIES

The aeronautical engineer is concerned with research in, and design and production of, all types of aircraft and parts. He usually specializes in one or more phases of the following branches:

Research—aerodynamics, hydrodynamics, aero engines, gas dynamics, gas turbines, supersonics, stress analysis, aeroplane parts and materials of construction, investigation of materials (alloys, metal, plastic and plywood); general layout of fuselage, hulls, tail, landing gear; weight control, production methods, tools and machinery.

Testing—Flight and performance testing, wind tunnel and flight load investigations, model testing.

Supervising—the assembly of airframes, and the installation of motors; instruments and other equipment; the technical phase of air transportation.

Air Transportation—communications; overhaul, inspection and maintenance of equipment; air line routes, schedules and traffic control; development and regulation of airways and their use; landing field equipment.

Other Specialties—Governmental regulations, including standards of design, construction, inspection and licensing of equipment; specification writing and patent development.

QUALIFICATIONS

Educational—minimum of Bachelor's degree in aeronautical engineering, or in some related branch of engineering; e.g. mechanical, civil, electrical, metallurgical.

In the case of Trans-Canada Air Lines, while a particular educational standard is not definitely stipulated for engineers' positions, an engineering degree from a recognized university is generally required. In several instances, T.C.A. technicians (non-professional) having long experience in specialized fields hold positions of responsibility equivalent to those of the engineers.

SPECIAL PROBLEMS

In all of the phases of his profession, the aeronautical engineer has been faced with the necessity of making an inexact science a bit more exact because of the stringent demands of the problems which he must solve. Every successful engineer must be a master of the art of compromise, but none to such an extent as the aeronautical engineer. The complications added to design by the extreme necessity of maintaining lightness, as well as strength and rigidity, and of meeting a widely varying and rapidly changing set of conditions involving variables such as pressure, temperature, acceleration and humidity, coupled with the ever-present problem of production simplicity, sometimes seem to make the compromise impossible.

Necessity has as usual brought forth inventiveness. The structural engineer and metallurgist have produced aluminum alloys weighing a little more than one-third as much as structural steel and having a yield point twice as high. But these alloys are as hard to handle as a thoroughbred. They must be machined and formed with extreme care to avoid scratching and resultant fatigue cracks. All but the most gentle forming must be done when the material is hot; but the heat must be closely controlled, since if the temperature is too low, forming is impossible, and if too high, the material will have reduced strength after cooling.

ORGANIZATION

Engineering Institute of Canada, 2050 Mansfield St., Montreal.

CERAMIC ENGINEER

MONOGRAPH 27

Ceramic engineering is a branch of applied science which has been developed in the United States and Canada, during the last 50 years, to meet the growing demand for the men necessary for the industrial production of non-metallic products made at high temperatures. In many respects, ceramic engineering is to non-metallic materials as metallurgical engineering is to metals. In North America, the trend of ceramic production has been linked more to the machine than to the craftsman, so that efficiency in methods of production and plant design have given the engineer ample scope for his talents. The training of a ceramic engineer must, therefore, include a detailed knowledge of the occurrence and properties of the raw materials with which he is concerned, such as clays, shales, feldspar, flint (silica), and also the numerous chemical compounds commonly used in ceramics. In addition, a background of mechanical, electrical, chemical, metallurgical, mining and combustion engineering are essential to his success.

At the present time ceramic engineering is only a small division of the engineering field.

INDUSTRIAL EMPLOYMENT

A brief reference to some of the more common ceramic products will serve to illustrate the type of operation in which the ceramic engineer may find his occupation.

In the production of *structural clay products* such as brick of all types, hollow structural tile, sewer pipe, flue linings, etc., the work of the ceramic engineer is usually confined to the larger plants where costly equipment and heavy production schedules demand his full attention. Smaller operators who are unable to afford the services of a full time engineer may require his assistance from time to time when difficulties arise.

In the *whiteware* industry where high grade clays are used in conjunction with other materials, the ceramic

engineer is needed to ensure the high quality of the products being made. Among the whiteware products are many well known classes of ware such as electrical porcelains for use as insulators on transmission lines and in electrical equipment, chemical porcelain, sanitary ware, chinaware, floor and wall tile, etc.

The production of *refractories*, made from fireclays, silica, magnesite, chrome-magnesite, dolomite, and a growing list of less common oxide materials, is a very important industry. Without good refractory materials, it would be impossible to carry on high temperature industrial operations such as the production of metals, portland cement and glass, or to operate industrial boilers. The production of synthetic abrasives such as alumina and silicon carbide and the subsequent shaping and firing of abrasive wheels and cutting tools is an important industry. The portland cement industry, even though its production methods are established and its processes well known, is a field which is open to the ceramic engineer.

The achievements of the *glass* industry have been well publicized and as one of the major branches of ceramics this offers many opportunities. The porcelain enamelling of metal in a wide variety of shapes, ranging from kitchen utensi'ls to bath-tubs, is an industry of increasing importance. A careful technical control of the process is essential to yield products that meet the requirements of colour, lustre and resistance to corrosion, abrasion and impact.

TRENDS

Relatively new fields of enterprise in which the ceramic engineer may anticipate the need for his services are the rock and mineral wool industry, and the production of light-weight aggregates from expanded shale and perlite for use in building materials. The demand for new types of ceramic materials or for combined ceramic-metal bodies in the construction of high temperature jet and gas turbine engines is also opening up new fields of opportunity.

The above outline gives some idea of the place of ceramics in the complex pattern of modern industry. In Canada, high grade clay deposits have not yet been developed and this has tended to inhibit the expansion of the ceramic industries. Cheap and abundant fuel is also a prime requisite for such industries. In spite of these disadvantages, the industries are making favourable progress in Canada, largely due to the zeal and ingenuity of its ceramic engineers.

ORGANIZATIONS

The Canadian Institute of Mining and Metallurgy, 906 Drummond Building, Montreal, Quebec.

The Chemical Institute of Canada, 18 Rideau Street, Ottawa, Canada.

CHEMICAL ENGINEER

MONOGRAPH 28

Chemical engineering can be defined as "that branch of engineering concerned with the development and application of manufacturing processes in which chemical or certain physical changes of material are involved. These processes may usually be resolved into a co-ordinated series of unit physical operations and chemical processes. The work of the chemical engineer is concerned primarily with the design, construction, and operation of equipment and plants in which these unit operations and processes are applied. Chemistry, physics, and mathematics are the underlying sciences of chemical engineering, and economics its guide to practice".

A unit operation is a physical procedure such as distillation or filtration. A unit process is a type of chemical procedure such as chlorination or oxidation. Most manufacturing processes are combinations of several unit operations and unit processes. The chemical engineer who has made a study of the principles of these unit procedures is therefore able to apply his skills in practically every process industry, and is not limited to a knowledge of only one industry. As an illustration, petroleum refining, the industrial production of oxygen, and the manufacture of alcohol all employ the unit operation of distillation as a basic processing method, although the raw materials and products of the three industries are entirely different.

It is not feasible, therefore, to list the industries in which the chemical engineer may find employment. It would, in fact, be simpler to list those in which chemical engineering can not be applied. If the reader of this article will look about him, he will see few objects that have not been influenced by the science of chemical engineering. Even the air he breathes may have been heated, cooled or humidified: heat transfer and humidification are two recognized unit operations of chemical engineering.

There is a general misconception that chemical engineering consists of about equal parts of chemistry and mechanical engineering. While it is true that chemical engineering overlaps these other sciences to some extent, it also covers a field that is not adequately dealt with by either of them. In industrial operations based on vaporization or extraction, for instance, the chemical engineer has the field to himself. The industries that employ both chemists and mechanical engineers, for example the petroleum refining industry, also employ large numbers of chemical engineers.

An analysis of engineers in the various industrial and service groups leads to the conclusion that there are about 1,800 chemical engineers in Canada at the present time, and this is confirmed by the fact that 1,729 were on record at the Bureau of Technical Personnel in January 1946.

FUNCTIONS

Some of the occupational functions within any given industry to which the chemical engineer applies his science can be classified as follows:

- Research and Development
- Production, Operation and Maintenance
- Management and Administration
- Inspection, Testing and Process Control
- Design, Construction and Installation
- Technical Service and Sales
- Consulting
- Estimation and Specification Writing
- Technical Writing and Editing

Of these the one employing the most chemical engineers is development. All the steps that are necessary to take a process from the laboratory to full-scale plant production are the concern of the development staff. Many new problems arise as the result of handling larger quantities of materials. The whole success of a process may depend, say, on the filtering characteristics of a material or on the extent to which a rate of reaction can be regulated by addition or extraction of heat. It is to development, therefore, that the chemical engineer can frequently apply his special capabilities to best effect.

QUALIFICATIONS

The required mental qualities are similar to those of many other branches of science and engineering. The chemical engineer requires facility for applying mathematics accurately to practical problems. Perhaps the greater part of his work will be setting up and solving problems involving the use of algebra, and he will also have to use calculus, trigonometry and other mathematical methods to a lesser extent. He cannot, therefore, be a successful chemical engineer if he lacks an aptitude for accurate numerical solution of mathematical problems and an understanding of the simpler branches of mathematics. The second desirable mental aptitude is versatility. The chemical engineer will be called upon to learn quickly the basic chemical and engineering factors applying to a very wide range of processes. He will not go as deeply into his studies as the chemist or physicist, but in general he will have less time to solve his problems, and they will cover a wider range of materials and techniques. The ability to grasp quickly the essence of a technical problem is, therefore, a major requirement.

The required qualities of character are also a consequence of the special nature of his work. It has been shown that the function of the chemical engineer is usually to undertake the development that is intermediate between discovery of the chemical and physical bases of manufacturing methods and the operation of the methods on a commercial scale. The chemical engineer must, therefore, co-operate with and reconcile the viewpoints and techniques of the pure scientist, on the one hand, and the manufacturer, on the other. His success in his profession depends to a large extent on his ability to co-operate with different types of men, and frequently to disagree with them on technical matters without arousing antagonism. This type of co-operation is a difficult art to acquire, and the student should ensure that he has an aptitude for it before he enters the profession.

ORGANIZATIONS

The Chemical Institute of Canada, 18 Rideau St., Ottawa.

Engineering Institute of Canada.

REFERENCES

"The Professions of Chemistry and Chemical Engineering in Canada", 1948, by Dr. L. H. Cragg, Department of Chemistry, McMaster University, published by "The Chemical Institute of Canada", gives much valuable statistical material.

The Chemical Institute of Canada: "The Economic Status of Chemists and Chemical Engineers in Canada", 1948.

CIVIL ENGINEER

MONOGRAPH 29

In looking back to the early white settlement of what is now Canada, we find the earliest references to engineers relate largely to "military engineers", who came over from France and later from Britain to construct forts, make surveys, construct roads and lay out towns long before Confederation. Civil engineering was the first civilian branch to be established as distinct from military engineering, as witnessed by the formation of the Canadian Society of Civil Engineers (now the Engineering Institute of Canada) in 1887. Thus it is the oldest and longest-established civilian branch of the profession, though it did include some members from other branches, such as mechanical.

NEED FOR NEWCOMERS

Of all branches of the profession, civil engineering is the one within which advanced age is the most noticeable. Forty per cent of those registered are now nearing the retirement age. This means that over the next few years the needs for replacement will be heavy, particularly in transportation, public utility and other branches of public service.

The student considering civil engineering as a career need not be over-concerned at the outset as to whether he will ultimately become a consultant, a structural designer, a contractor, a city manager, a top flight salesman, an industrial executive or a top civil servant. The main thing is to get a start where he will see how things are done and where he may apply the fundamental principles he has learned at college to the problems arising in his day-to-day work.

FIELDS OF PRACTICE

A glance through a list of activities within the profession which provide engineering employment shows a great variety of choice. *Construction*, with today's volume

at an all-time record, heads the list, and includes employment in contractors' organizations or with utilities or government services that today undertake construction with their forces. *Railway transportation* uses a lot of engineering talent, though to a lesser extent than a few decades ago during the railway building era. The demand for civil engineers through the development of new sources of *hydro-electric power* will continue for many years to come.

Municipal engineering offers many openings. Our accelerated population growth and the upward trend both now and in the short-term future in housing accommodation is fast using up any surplus capacity of existing waterworks, sewers, streets, airports, transit facilities, calling for huge expenditures for reservoirs, aqueducts, sewers and disposal plants, paving and other service facilities. Here and in power development lie the best opportunities for the student interested in hydraulics. Even *communications* call for a reasonable proportion of civil engineering employees.

Provincial highway departments, as well as *public works departments* both at Ottawa and in every province are in the market for many more young civil engineers. A large proportion of the civil engineers in these departments are near retirement age.

Irrigation and Drainage is another field that offers an interesting career, particularly in the Western provinces and to some extent (for drainage) in the Maritimes. Surveying practice in combination with municipal engineering offers opportunities for a definite number of civil engineers.

Sales and service organizations in many an industry are a natural outlet for the talents of the civil engineer. Hydraulic and road-building machinery, railway rolling-stock, farm implements, building materials, all types of construction equipment, and appliances used for water and sewer systems; these are a few of the more obvious products that come to mind, where the young civil engineer should make a success at selling. Even in insurance, with its need for valuations, appraisals, inspectors

and rate setting, the man with training as a "civil" is at a definite advantage over those who lack it.

Community planning is a brand new field which should increasingly require engineering recruits. A further limited prospect for employment of "civils" arises in *municipal management*. A fifth of all cities of 10,000 population and under in the United States, as well as a quarter of the larger cities, have adopted the city manager system of government, thus providing an eminently suitable place for the civil engineer, particularly those who desire to establish a home life and interest themselves in community affairs.

ORGANISATIONS

The Engineering Institute of Canada, 2050 Mansfield St., Montreal, P.Q.

ELECTRICAL ENGINEER

MONOGRAPH 30

During the last fifty years, electricity has been the major factor in the phenomenal growth of industrial production of material wealth in Canada. The enormous electrical power developments that were carried through to completion in that period represent, however, only about 25 per cent of Canada's known water-power resources, and it can be confidently predicted that for years to come we shall see continuous and increasingly rapid development on the remaining 75 per cent, thus assuring a correspondingly strong and stable market for the services of electrical engineers.

Electrical engineering in the power field is concerned with the generation of electrical energy, its transmission and distribution, transformation, control and measurements, and utilization. Its chief branches may be set forth as:

1. Power Systems
2. Manufacturing and Mining
3. Transportation
4. Electrochemical
5. Illumination

Another type of breakdown gives main divisions as follows:

A. Education

B. Research

C. Design and Consultation

D. Sales

E. Operation and Maintenance

The ramifications of electrical engineering are so extremely broad that no engineer can hope to attain a "saleable" knowledge of more than a small segment of the field.

SPECIALIZATION IS BOTH LOGICAL AND INEVITABLE

The term "specialization" should not be interpreted as implying a *narrow* range of knowledge or interest, since on the contrary it usually calls for a *broad* range; for example, engineering skill in the design of large synchronous generators, involves not only the thorough knowledge of the principles and practices underlying the electrical design of synchronous machines, but also an equally thorough knowledge of:

1. Relation between generator design and system stability
2. Magnetic and physical properties of materials
3. Bearings and lubrication
4. Heat transfer, air flow and ventilation
5. Insulation, theory, materials and processes
6. Balancing and vibration
7. Windage, friction, noise
8. Welding and brazing
9. Costs of materials and manufacturing processes
10. Manufacturing system and methods
11. Tool design
12. Brake design
13. Generator relay and lightning protection

The electrical engineer's required knowledge frequently embraces substantial areas of other fields such as mechanical, metallurgical, or chemical. For example, in designing a high voltage, reclosing oil circuit-breaker, the engineer has the mechanical problems involved in unlatching the mechanism, accelerating the mass of movable parts to break contact and move sufficient additional distance to allow the arc to be extinguished, then reverse the direction of motion and reclose the circuit—all within less than ⅓ second total time.

In Canada, employment on pure research in the power field of electrical engineering has been negligible, and there is no indication of any immediate change. The continued and notable evolution in the generation, distribution and utilization of electrical energy can however be truly term-

ed the result of continuous research by Canadian engineers employed by utilities, manufacturers (especially those producing heavy electrical power equipment), and consulting engineers. Practically all design and consultation work is carried out by the engineers in this group. The designs of specific types of apparatus and co-ordinated groups of apparatus are produced almost exclusively by design engineers in the employ of manufacturers of electrical equipment.

Canada has many large electrical utilities, and their operation requires very large engineering staffs to handle the necessary forecasting and planning, design, construction, operation, and power sales. Water-power, steam and diesel engines are all used as power sources, but water-power outstrips the others by a very wide margin. This usually means that high voltage transmission lines are required to bring the power to load centres.

Canadian industry is heavily electrified, and while manufacturers of electrical equipment have undoubtedly the greatest need for large staffs of electrical engineers, there are many other types of industry that also require substantial electrical engineering staffs. The quantity of electrical power and the complexity of the electrical systems and electrical drives used by modern paper, steel, non-ferrous and textile mills, chemical and automobile plants, mines, etc., is very large—sufficiently so to demand planning and operation by professional engineers. The constant trend towards the supplanting of labour by automatic operations will correspondingly increase the need for trained engineers.

The complexity of the equipment used for the generation, distribution, utilization and control of electrical energy gives a very large field for engineering employment in the selling of such equipment. Whether or not the purchaser has his own engineering staff, it is still necessary for the commercial man to be thoroughly versed in the application requirements and the engineering features of the equipment he is handling, and capable of making sound recommendations to his clients.

The electrical engineer specializing in illumination work may be concerned with lighting in homes, offices, or industrial establishments, airports, freight yards, playing fields. The work of the illumination engineer ranges from research through design to application. It is probable that the major portion of employment is in connection with application and the corresponding selling activities. Airport lighting systems owe their present satisfactory stage of development to the electrical engineer.

A small but very important and intriguing area of electrical engineering activity is "measurements". Nearly every activity with which the electrical engineer is concerned involves measurement, either for control or metering purposes. The electrical engineer is responsible in many cases for the design and manufacture of the necessary instruments.

An appreciable number of engineers find interesting employment in the large field covered by the design and merchandising of household electrical appliances. Items such as electric refrigerators, washing machines, and ironers, are reaching the class of necessities, and the engineer faces the challenge to continually produce new devices and better devices.

The electrical engineer has wide scope in the transportation field. The street car still holds its own when operating under suitable conditions, and the trolley bus is an important aid in solving urban transportation problems. Diesel electric locomotives are in high favour for switching operations. The Prince Edward Island Ferry "Abegweit" is an outstanding example of the possibilities of electrical ship propulsion.

A little known subject in electrical engineering is "switchgear" with a range of devices ranging from the high voltage circuit-breaker to automatic controls guided by supersensitive relays with almost human intelligence, that can take care of anything from a large generating station to a paper machine drive.

The field of communications is one of the major divisions of electrical engineering. It consists of 3 major sub-divisions:

Telegraph
Telephone
Radio

The telegraph industry was the first to develop, reaching its peak rate of expansion of facilities before 1900. It has continued to grow and many improvements have been added, including the multiplex system which permits the sending of many messages at the same time, the teleprinter, automatic relaying and finally automatic telegraphy. The telegraph industry is still very important as it carries a large share of today's volume of messages. Comparatively few electrical engineers are employed in this industry, mainly on research and development projects and to some extent on maintenance.

The telephone industry's development is characterized by many technological improvements, many of which were developed by electrical engineers. Engineers are not used to any great extent in this industry in the operation of the system itself. Generally, their major functions are research and development, and the solving of problems surrounding the expansion of facilities. The industry will undoubtedly expand in the future. The introduction of improved facilities (such as co-axial cable) will contribute to the growth of the industry. Employment of engineers is not expanding much.

Since 1920 the radio industry has been expanding very rapidly. The number of engineers in radio broadcasting has been increasing, and the introduction of frequency modulation and television will undoubtedly cause further increase.

A high proportion (perhaps 40 per cent) of the electrical engineers employed in the communications industry group are engaged in research, design, development and similar functions. In the telephone industry, for example, these positions cover a wide range from that of an engineer developing a new piece of equipment to an engineer

making a critical study of a telephone plant to obtain cost data. About a third of communications engineers are in management positions. About 15 per cent are employed in work dealing with operation, inspection, maintenance or installation.

Considering all three parts of the communications industry, employment of electrical engineers is not expected to increase very much. The number of telephones is expected to increase considerably, but this expansion will not require a proportionate increase in engineering employment. Radio broadcasting and allied fields offer the best chance for increase in the use of engineers.

There are hundreds of facets to electrical engineering, and whether in power generation and distribution, manufacturing, design, communications, research or sales, each and every one can be of fascinating interest and a source of satisfaction to the true engineer's inherent desire to do something thoroughly worthwhile.

TRENDS

The number of electrical engineers in Canada increased between 1921 and 1941 at a rate of over four times that of the population growth as compared with a rate of about twice the population growth for the engineering profession as a whole.

In the period from 1920-1944 a total of 2,970 students graduated as electrical engineers in Canada.

Evidently the trend towards an increasing interest in this branch of engineering is continuing. In 1941 the percentage of electrical engineers in the engineering profession was about 22; in 1946 the percentage of veteran students registered in the engineering courses who expressed their intention to become electrical engineers was about 27. Consideration should be given to the possibility of overcrowding if this trend continues.

Unlike civil engineering, this branch of the profession does not have a high percentage in the upper age group. The percentage of persons over 55 in electrical engineering

is about the average for all occupations (17 per cent). In January 1946, out of 4,013 whose ages were on record there were 682 over 55 years of age, and there were 690 between the ages of 45 and 54. It appears, therefore, that openings created by retirement will be more numerous in some of the other branches of the profession than in electrical engineering.

PROFESSIONAL ORGANIZATIONS

The Engineering Institute of Canada, 2050 Mansfield St., Montreal, P.Q.

FOREST ENGINEER AND FOREST SCIENTISTS

MONOGRAPH 31

The forests of Canada are of primary importance in the economic development of the country, covering as they do more than one-third of the total land area.

Productive forests contain 813,100 square miles, of which about 435,000 square miles are considered to be accessible. Nearly 70 per cent of the total accessible stand comprise softwood species. Softwoods, or coniferous species, supply the greater part of the world demand for wood products, and Canada possesses the principal reserves of this class of timber within the Commonwealth.

The Statistical Record of the Forests and Forest Industries of Canada, 1947, published by the Dominion Forest Service, Department of Mines and Resources, gives the following figures as to accessible timber of merchantable size in Canada:

	Saw Timber	Smaller Material	Total
	Millions of feet board measure	Thousands of cords	Thousands of Cubic Feet
Maritime Provinces	15,555	109,905	12,452,925
Quebec	55,500	629,450	64,603,250
Ontario	53,950	559,930	58,384,050
Prairie Provinces	15,505	199,135	20,027,475
British Columbia	109,740	186,290	35,879.900
Total	250,250	1,684,710	191,347,600

The occupied forested areas comprise 269,420 square miles of which 47.2 per cent are held under pulp and paper licences, 9.4 per cent under saw timber licences, 6.2 per cent under timber sales and permits, 24.3 per cent are owned by corporations and other private interests and 12.9 per cent are classed as farm woodlots.

Total depletion of merchantable timber averaged about 3,300,000,000 cubic feet annually for the ten-year period 1937 to 1946. In the same period wastage by fire,

insects and fungi averaged 853,500,000 cubic feet, varying from a peak of 35.8 per cent of the total depletion in 1936 to 17.2 per cent in 1946.

Lumber production in Canada reached an all-time high in 1947 when an estimated 5,346,000,000 board feet were produced. About 45 per cent of this production comes from the Coast Region of British Columbia. Exports of lumber amount to almost 40 per cent of the total output.

The manufacture of pulp and paper is considered one of Canada's leading manufacturing industries, and its products form the main items in our export trade. Newsprint paper, the most important product of the industry, reached a record production in 1947 of about 4,446,800 tons, of which 95 per cent is exported.

In comparison with the export trade, the amount of forest products imported into Canada is relatively small. In 1947, a favourable trade balance of $797,517,879 resulted from the traffic in wood, wood products and paper.

TRENDS

While it is probably true that exploitation with only minor consideration for future growth may have been unavoidable in the pioneering period in Canada, and a necessity during hard times, nevertheless the desire to realize immediate income from forest holdings has led to a depletion of forest capital in the more accessible regions, and the neglect of the more remote areas.

The activities of the forest services maintained by the Federal and provincial governments are confined largely to Crown lands, although aid is given to farmers and other woodland owners in advising on principles of forest management. The more progressive owners and lessees of timbered areas have their own trained staffs, but the more conservative have been slow in the past to replace their practical non-professional executives by trained engineers. The forest engineer, possessing both scientific and practical knowledge, is well qualified to act as the administrative or executive forest officer for both governmental and private interests.

Federal responsibility in forestry is mainly expressed in the contributions made by the Dominion Forest Service through fundamental research in forest protection, economics, silviculture, air survey and forest products. Since certain forestry problems are common to several provinces, research work by the Dominion is complementary to provincial activities and integrated for the development of a national forest policy. The national parks and forest experiment stations controlled by the Dominion Government comprise about 30,000 square miles.

All other Crown lands within their boundaries are controlled by the provincial forest services. These services are responsible for the protection of the forests, the disposal of timber and the control of cutting operations, building and maintenance of forest roads, surveys and mapping, and the management of game, fish and recreational facilities.

The large corporations, especially those in the pulp and paper industry, employ professional staffs on soil surveys, air-photo surveys, silvicultural research, watershed protection, and marketing and utilization. Reforestation of cut-over areas is contemplated by some companies as soon as the conditions of tenure are adjusted by new legislation.

A growing interest is manifesting itself on the part of the public in the preservation of the forests as a source of wealth and a means of protection both for the present and for future generations. Governments and industry alike are undergoing the transitional stage from unrestricted exploitation to sustained yield forest management.

A prominent official in the lumber industry states that the old-time "timber cruiser" is dying out, and that those remaining are in the older age brackets. These men will no doubt be replaced by professionally trained forest engineers who will of necessity have a thorough practical experience in all phases of lumbering.

The Pulp and Paper Association of Canada issued a statement on Forest Policy in 1946 which is sometimes

referred to as the ten-point policy, and is summarized as follows:

1. Surveys and Inventories of Forest Resources

There should be complete information through aerial photographs and surveys on forest resources so that long-term planning will be possible.

2. Forest Management

Each forest operator in the industry should examine the forest area serving each producing unit to determine its present and future ability to supply the needs of that unit in perpetuity. Sound sustained yield forest management will be more quickly achieved if it is recognized that the adoption of a forest management policy cannot be effective if it involves the sacrifice of production and employment.

3. Forest Protection

Losses of wood supplies from fire, insect infestation and disease should be reduced through the co-ordinated efforts of the forest industries and the Dominion and provincial government departments. Present expenditures for this purpose are not commensurate with the value of Canadian forest assets.

4. Silviculture

Government activities and those of industry associations should be extended to provide and disseminate the scientific knowledge necessary for maximum wood production.

5. Use of Forest Products

Encouragement and support will be given government and industrial efforts in forest products research and the wider use of information already available. Logging operations should be integrated to cut and deliver most efficiently all disposable products.

6. Mechanization of Logging

Support will be given in co-operative research and experimentation in order to increase the efficiency and reduce cost of logging by the introduction of mechanical equipment.

7. Forest Labour

There should be greater stability and more efficient utilization of the woods labour force. Steps will be taken to intensify the training of men in efficient logging techniques and other basic forest operations.

8. Forest Land Tenure

This industry will advocate a policy of land classification so that areas suitable only for forest growth can be permanently set aside as forest areas which will permit of proper execution of a long-term forest management policy.

9. Forest Finance

This industry will seek to determine and make suitable arrangements with governments for financing projects for the forest development and protection required by a sound forest policy.

10. Private Land

This industry will seek to encourage efficient forest management on private lands and to develop pulpwood production on these lands to ensure a regular and sustained supply of improved quality.

Future Employment Prospects

The implementation of the above-mentioned policy will depend on the supply of trained forest engineers. In 1947 there were approximately 900 persons in Canada who possessed the basic qualifications of forest engineers or forest scientists. About 45 per cent of them were employed in the Dominion or provincial forest services, 25

per cent were with pulp and paper companies, 15 per cent with lumber concerns and 5 per cent were engaged in teaching or research. The remaining 10 per cent were in other types of employment.

For many years, the average number of men graduating annually has been 32, but this number is expected to be greatly exceeded during the period 1948-1951. The universities have enrolled as many as they can accommodate including 730 veterans of whom approximately 370 are expected to graduate in 1949, and the remainder in 1950.

In view of the present large enrolment in forestry, men contemplating entering the profession should investigate carefully the possibility of employment upon completion of training.

DUTIES

Broadly speaking, it is the function of the profession of forestry in Canada to protect and manage the forests in such a way that they will contribute as much as possible to the welfare of the Canadian people, both now and in the future. The individual forester may find himself concerned with forest management in its technical sense; he may specialize in the protection of forests from damage by fire or insects or diseases; he may engage in research; or he may be employed in surveying and cruising timber or in conducting logging operations. Under certain circumstances, and especially if he is engaged in logging, the forester's work will include much engineering; on the other hand, the forester engaged in silvicultural research will rely mainly on that part of his training which was concerned with biological subjects.

There is a trend toward specialization in operational work, forest entomology and plant pathology, silviculture, hydrology or wood technology, after the basic training has been completed.

In an organized service, a forest engineer can hope for advancement to positions of greater responsibility by the expansion of the service, by seniority, and by merit.

The Dominion Forest Service, for example, has five grades of forest products engineer, and six grades of forest engineer. In addition, there are higher administrative positions. Each of the provincial governments, with the exception of Prince Edward Island, has its own forest service. As the provinces control their own natural resources, which include most of the accessible timber, opportunities in provincial forest services are encouraging. In private employment, a forest engineer may advance to an executive or administrative position either in his specialty or in the general management of the company.

ORGANIZATIONS

The Canadian Society of Forest Engineers (Secretary-Treasurer, C. Cooper, 10 Manor Road West, Toronto).

The Engineering Institute of Canada, 2050 Mansfield St., Montreal, P.Q.

The Canadian Forestry Association, 1018 Canada Cement Bldg., Montreal, P.Q.

MECHANICAL ENGINEER

MONOGRAPH 32

The mechanical engineer may invent, design, manufacture or sell machinery, or he may perform some combination of these functions. He may do none of these, but he may be fitted through his special training to engage in the operation or management of plants containing many kinds of mechanical equipment for the production of the things we use.

If we consider our natural resources and how much the utilization of them has been mechanized, we may well offer encouragement to the young man who "likes making things" to pursue the study of mechanical engineering. For example, it is the electrical engineer who designs the electric generators, transformers, switchgear and transmission lines for a large power development, but the mechanical engineer's services are required to design and build the turbines to drive these generators and even the machines used in their manufacture. To convert the energy in our coal to steam or electricity, the mechanical engineer is required first in the mines to provide the machinery to cut and remove the coal from the earth, and to design and build the transportation equipment, whether it be ships or trains, to move it to its point of use.

From there it is he who designs and builds the boilers and turbines to transform the locked-up energy in the coal into useful forms. In our forests the trees are cut down and removed mechanically, and the mechanical means to convert them into paper or rayon or plastics call for the ingenuity and special knowledge of the mechanical engineer, as well as that of the chemical and electrical engineer. In our mines it is the same story, as well as in the garnering of our crops and in their conversion into food and other essential products.

THE FIELD OF MECHANICAL ENGINEERING

Mechanical engineering may be divided into two main subdivisions: power generation in its several forms, and

the manufacture of machinery, both consumer and capital. The primary power runs the full range from water power through steam and internal combustion engines to tidal and wind power. The machinery will vary from delicate precision instruments to the heaviest earth-moving equipment. Of course the mechanical engineer shares to a greater or lesser extent this field with other branches of his profession. The work of mechanical, civil, electrical engineers and others must be closely co-ordinated in the development of a hydro-electric installation. The chemist, metallurgist, etc., contribute to the internal combustion engines. But the mechanical engineer also shares the fields which at first glance fall into other hands. He has an entrance into most endeavours through his role as industrial engineer or as machine designer.

In the field of power, steam generation plays an important part. In Canada little steam-generated electricity has been produced as yet except as a by-product of steam for heating and processing. We are particularly fortunate in our water power resources, but some steam-power generating stations are already making their appearance for stand-by purposes.

In steam-power plants the mechanical engineer deals with fuels and their combustion, boilers and their settings, superheaters, stokers, conveying systems for fuel and ash. He is familiar with draft problems, lubrication, condensers, feed water heaters, pumps, piping systems. For steam-generated electric power his are the problems of the prime movers. He is familiar with reciprocating and turbine types and must be able to use several of each to advantage. In the field of steam-power generation the mechanical engineer is supreme.

An important source of power is the internal combustion engine, and it has made unique contributions, particularly in mobile forms. Here the mechanical engineer deals with fuels, detonation, combustion chambers, carburation, etc. His problems range through cooling, lubrication, vibration and performance. His endeavours have resulted in such contrasts as the rugged slow-turning diesels generating cheap electrical power and the incred-

ibly powerful aircraft engines where every ounce of excess weight has been virtually eliminated by the use of alloyed materials daringly stressed. Possibly no field of engineering is as rapidly advancing today as the internal combustion engine. Gas turbines, jet and rocket engines are regularly establishing new speed records in the air, and now that the barrier at the speed of sound has been penetrated the limit appears to be nowhere in sight.

Heating and ventilation is a rapidly increasing field open to the mechanical engineer, and has a peculiar significance for residents of Canada. Here subjects will range from the largest of sky-scrapers and office buildings to the smallest of prefabricated dwellings. The mechanical engineer deals with the nature and measurement of heat, heat losses from buildings, temperature gradients, insulations and methods of heating. He must understand the properties of air and the principles and methods of ventilation. Changes in methods of heating are having a marked effect on architecture as buildings become more functional. The words "radiant" and "solar" heating, "air conditioning" are new-comers in the language and reflect the progress of the mechanical engineer's solution to his problem.

A field of specialization for the mechanical engineer is that of machine design. He must have a knowledge of the pattern shop, the foundry, the machine shop and the assembly floor. If his designs are to be practical he must have a keen appreciation of the limitations of each step in production, and over all he must maintain "eye appeal". Even the most down-to-earth equipment must "appear" correct if it is to find a market.

More highly specialized is the study of stress analysis. Particularly in high-speed equipment and where weight is an important consideration, stressing must be accurately calculated. Here the problem of stress concentration and fatigue haunt the designer. Models, both scale and full size, are studied for analysis. Strain gauges, brittle coatings, and transparent sections under polarized light all make their contributions to stress studies. Stimulated by the aircraft industry, stress analysis is

making progress throughout industries which not long ago were content to design by "rule-of-thumb". It fills a large place in machine designing.

An important field for the mechanical engineer is in production. His is the problem of producing what the designing engineer has established. His control starts with the inital layout of the plant and the choice of the proper equipment. He processes the parts and often requires their redesigning to effect efficient and practical production. His is the responsibility for scheduling the parts to assure delivery of the finished equipment in the proper order and when wanted. His problems start with raw material procurement and continue through to shipment and delivery. Wage systems, time studies, incentive plans and personnel all come under the general heading of production. In an age of industrial strife the engineer, with his opportunity to understand the shop man's problems as well as the overall objectives of the plant, is in an unique position to render a real service to both management and labour. He can be expected to fill a large role in labour relations in the future.

PROFESSIONAL ORGANIZATIONS

The Engineering Institute of Canada, 2050 Mansfield St., Montreal, Quebec.

METALLURGICAL ENGINEER

MONOGRAPH 33

Metallurgy is one of the oldest arts and one of the younger sciences. There are numerous early references to metallurgists. Genesis IV, verse 22, mentions "Tubal-cain, an instructor of every artificer in brass and iron". The metal relics of the ancient civilization of both Europe and Asia indicate that the work of the metallurgist had attained a standard truly amazing, when one considers the primitive equipment and facilities at his disposal.

Any country's state of industrial development and standard of living is directly proportional to its *per capita* consumption of metals. The importance of the metallurgical engineer or metallurgist (terms which are often used interchangeably) to society cannot be over-emphasized.

Almost all minerals as they come from the ground require some treatment to make them or the metal content suitable for the use of man. In most cases the treatment consists of complicated and extensive processes. Take iron ore as an example. First the ore must be broken up to the required size and then it is treated in a blast furnace with limestone and coke to produce pig iron. This product is further treated in reverberatory furnaces or Bessemer converters to produce steel.

DUTIES

The metallurgical engineer is concerned with the science of metals which embraces the constitution, structure, and properties of metals and alloys. This covers a wide range of activities, the most important of which are as follows:

1. Mineral Dressing, the concentration of valuable minerals from their ores.
2. Process metallurgy, the recovery of metals from ores, concentrates, and secondary sources.

3. The conversion of metals and alloys into useful shapes, commonly called the metal-fabricating industries.

4. Heat treatment and mill processing.

5. Management of metallurgical plants.

6. Research.

7. University Teaching.

Mineral Dressing has a wide application in the mineral field. It includes the crushing and grinding of ores, and the metallurgist must know the types of equipment most suitable to give the required results for any given type of ore. Separation of the valuable from the valueless constituents of the ore requires the use of a wide variety of concentrating machines and processes. Flotation is employed not only to concentrate the valuable minerals in the ore, but to separate and differentially concentrate two or more valuable minerals in the same ore. The separation of the nickel and copper sulphides, and the separation of lead and zinc sulphides, are made possible by the process of flotation.

Process Metallurgy includes the smelting operations to produce metals from ores and concentrates obtained by mineral dressing. It also may include roasting operations to remove sulphur or arsenic from the ore before it is smelted. To produce high grade metal, refining is required, and this is usually done by electrical methods, known as electrolytic refining. Copper, nickel, lead, and zinc are all produced in Canada by electrolytic methods.

Metal-fabricating covers a field in which the metallurgical engineer assumes an important role. The rolling of metal and metal alloys into sheet and the use of die casting and precision casting all present scientific problems for the metallurgist.

Heat Treatment and Mill Processing are important branches of the steel metallurgist's functions. This includes the hardening of steels and the changing of their physical properties to render them more suitable to meet the requirements of the services for which they are required.

Research in any of the above branches of metallurgy is carried out in universities, government departments, and in many industrial plants.

University Teaching offers a limited number of positions. Practical experience in some commercial metallurgical field is a necessary prerequisite for the taking up of a teaching career.

OPPORTUNITIES

Metallurgy offers an opportunity, beyond the ordinary, for initiative and invention. The scope is limited only by the laws of science, thus offering an extremely broad opening to those who combine scientific knowledge with an instinct for research.

Openings for metallurgists are found in all industries which produce and process metals and alloys, and industries which fabricate them into producer and consumer goods; service industries which provide transportation, communication and power; branches of the government service; educational institutions; commercial laboratories, and industrial research institutes.

Advancement depends on ability, initiative and industrial opportunity.

TRENDS

Canada is one of the greatest metal-producing countries of the world, and as her industrial development progresses, the demand for metallurgical engineers will increase.

ORGANIZATIONS

The Canadian Institute of Mining and Metallurgy, 906 Drummond Building, Montreal, Que.

MINING ENGINEER

MONOGRAPH 34

Mining is one of Canada's great basic industries, comparable to forestry and agriculture. Minerals provide the raw materials for a large part of our manufacturing industries. The cement, bricks, plaster, glass, and plumbing for our homes and the coal to heat them; the steel for railways, ships, and automobiles; and copper for electrical transmission; the aluminum for aeroplanes; the oil and gas for heat and motive power;—these and hundreds of other materials used on land, sea, and in the air are mineral products.

Minerals support a large part of our export trade. Without them, we should be very much restricted in our purchases of fruits, cotton, wool, and a thousand-and-one other supplies that we obtain so conveniently from abroad in exchange for our mineral products.

The primary production of minerals employs about 77,500 persons, which is only a small fraction of those needed in the plants and factories in which the minerals are worked up into the forms of every day use. The management and scientific direction of the mineral industry are in the hands of a comparatively small group of men trained in our universities. We will confine our remarks in this monograph to the Mining Engineer. The Metallurgical Engineer and the Geologist have been dealt with in previous monographs.

The mining engineer is the man who "runs the show". His training is broad, as he must be prepared not only to develop and operate a mine and mill, but to manage his labour, lay out a townsite, provide a proper water supply, see that the families can get adequate supplies, and supervise the bookkeeping. The manager's job is the one to which the majority of mining engineers aspire.

When a mine is just emerging from the stage of being a prospect, it is possible that one mining engineer can manage it and provide the other technical services. But

at most mines there is a staff, including an underground superintendent, a surveyor, an assayer, a mechanical and electrical superintendent and a mill superintendent. In large mines there are good positions for young technical men as mine captain, foreman and safety engineer.

A mine manager has a responsibility beyond the ordinary, and is well paid. The salaries of the mine staff are higher than the average for technical men.

A successful career in mining requires, perhaps, somewhat more initiative and independence of spirit than is needed in occupations of a more settled nature. Every mine has a limited life, and when the ore is worked out, the staff must move on to another job. While many mining communities have grown to the size of cities, most of them are relatively small, and many are in isolated localities. There is therefore plenty of room for those with the pioneering spirit. Today the mines, mills and smelters are staffed almost entirely by men with technical training, so that a college education is almost an essential for progress.

The Mines Acts of several provinces require that every person employed underground must be free from diseases of the respiratory organs and medically certified to that effect. In addition, the various Coal Mines Regulations Acts require coal mine officials and certain classes of operatives to obtain Certificates of Competency through examination by the Provincial Departments of Mines before they are permitted to undertake these functions. A graduate mining engineer may obtain all such certificates by writing the one examination for First Class Mine Officials for coal mines, but, as lengthy experience in and about a mine is a prerequisite, it is highly desirable that as much experience as possible be found during vacations, or otherwise, prior to graduation.

TRAINING

While a university degree gives the best possible start in the profession, it is only a start. Undergraduates usually work in the summers at jobs connected with

their future work—such as underground as muckers and machine men. This practical experience is invaluable.

ENTERING THE PROFESSION

For some years after graduation it is necessary to learn the more practical side of the work in some junior position. The mining engineer may be a mine surveyor or conduct the sampling of the mine, or may become a shift-boss, which is the surest way to the post of superintendent or manager.

ADVANCEMENT

As the mineral industry of Canada is at present in a period of expansion, the chance for advancement in the profession is probably better than average. It depends largely upon personal abilities and adaptability. The ability to handle men is one of the principal reasons for rapid advancement. This applies not only to an aptitude in handling workmen, but also to the faculty of getting along with those in the more senior positions, right up to the general manager and directors of the company.

ADVANTAGES AND DISADVANTAGES

Those who like city life had better steer clear of the mineral industry. While there are some exceptions, it usually involves living in a mining town, which may be a city such as Sudbury or Trail, a town such as Val d'Or or Flin Flon, an isolated camp such as Britannia Beach or Port Radium, or a frontier post such as each of these was in the beginning. In the smaller places, the life holds much of adventure. In the larger centres, it is much like that of any other town.

Mining engineers are probably more subject to moving around, both within this country and abroad, than are other engineers. This change of scene appeals to only a limited number of young men. It is essentially an adventurous type that fits into this industry.

GROWTH OF THE MINING INDUSTRY

In 1871 the value of Canadian mineral production was about \$3,000,000. In 1948 it was estimated at \$800,000,000.

The expansion is still continuing, and as exploration extends farther northwards new discoveries are being found that will require the services of mining engineers for their development. The recently proved iron ore deposits of Ungava and Labrador have changed the entire picture of Canada's iron ore economy. Vast titanium ore deposits in Quebec are about to be developed. Renewed activity in old mining areas, due to the increased price of base metals, along with expansion of producing mines, all contribute to a demand for trained mining engineers.

NUMBER IN THE PROFESSION

In 1946 the Bureau of Technical Personnel recorded 2,414 mining engineers. In 1947 and 1948 there were about 140 new graduates in mining engineering.

AGE DISTRIBUTION

In 1946 the proportion of mining engineers aged 55 or more was 23%; this compares with 18% for the gainfully employed population generally. Approximately 15% were between 45 and 55 years of age.

FLUCTUATIONS IN EMPLOYMENT

A substantial drop in base metal prices may force suspension or reduction of production in some mines; and non-metallic products may, in times of economic maladjustment, be in low demand. Gold will, under existing international financial conditions, continue to be produced. There is no present indication that any long periods of unemployment are likely. 89 per cent of the Dominion still awaits geological exploration.

ORGANIZATIONS

The Canadian Institute of Mining and Metallurgy, 906 Drummond Building, Montreal, Quebec.

PETROLEUM ENGINEER

MONOGRAPH 35

The development of the internal combustion engine and its ever-increasing use in road, air and sea transport, and also the growing use of oil for firing boilers and furnaces, have made oil production one of the most vital industries in the world.

The marked expansion since the end of the war in petroleum production in Western Canada, especially in Alberta, and the consequent impetus to prospecting, have resulted in an increased need for petroleum production engineers.

Since this need is to a great extent a new one, and this branch of the profession has been a very small one numerically in this country, it is only recently that a university course of study has been set up in Canada.

DUTIES AND SPECIALIZATIONS

Since there is some misunderstanding concerning the field of petroleum engineering, it should be explained that engineers are engaged in two branches in connection with petroleum and its products, that is, petroleum refinery engineering and petroleum production engineering.

Petroleum refinery engineering is not considered a major division of engineering but merely chemical engineering applied to the petroleum processing industry. Those interested in this field would be well advised to study the more general field of chemical engineering.

Petroleum production engineering is that branch of engineering founded on the basic sciences of physics, chemistry, geology and mathematics which is concerned with the problems of development and exploitation of oil and gas fields. More specifically it is concerned with:

(a) **Oil and Gas Field Development**

Properties and occurrence of petroleum—petroleum exploration methods—reservations and leases—field definition—well spacing—drilling equipment and methods (standard, rotary, casing and casing methods, fishing)—exclusion of water—well finishing—well records.

(b) **Oil and Gas Field Exploitation**

Drainage—reservoir mechanisms—flowing wells and their control—pneumatic pumping—mechanical lifting devices—operation for maximum economic recovery (conservation—secondary recovery methods—preliminary refining—gathering and storage—transportation).

The petroleum engineer, according to the United States National Roster of Scientific and Specialized Personnel, is concerned with "the search for new fields, the drilling of wells and the production, storage and transportation of crude oil and petroleum products".

The description continues "Prospecting for oil may be performed by a geologist or geophysicist as well as by the petroleum engineer. The methods employed include the examination of outcroppings and core samples and the more exacting geophysical techniques which include the use of gravimetric, seismic and electrical methods. Upon the basis of data obtained, the engineer passes upon the commercial feasibility of the area. Once oil has been found in paying quantities, the engineer initiates and directs well-drilling operations, and the erection of such facilities as derricks, rigs and tanks for the control of the flow and storage.

"The petroleum engineer may likewise design and construct pipe-lines and supervise the pipe-line transportation of oil to the refineries".

TRAINING

Though a number of universities in the United States provide courses in petroleum engineering, the Department of Chemical Engineering of the University of Alberta now gives the only course in Canada.

In comparison with chemical, civil, electrical and mining engineering, the Alberta petroleum engineering curriculum contains more training in geology than any of the others, about the same training in physics and mathematics as chemical engineering, and slightly less training in chemistry than chemical engineering, but certainly more than is given in civil, electrical and mining engineering. Basic knowledge courses include materials, machines, structures and processes common to all divisions of engineering, with emphasis on those encountered in petroleum engineering work.

In addition to his training in engineering materials, elementary mechanical engineering, hydraulics and related studies, the petroleum engineer should have detailed instruction in the properties and behaviour of pipe, tubing and casing, of porous and permeable rock formations, etc.

He should become familiar with machines and structures peculiar to his specialty, but detailed training in this direction is not desirable, since this type of "clinical" knowledge is better obtained through practical experience. Additional study should be made of such chemical engineering unit processes as fluid flow (especially that of liquids, vapours and gases through porous media, and of muds, liquids and gases through pipes), heat transfer, gas absorption, distillation and related matter.

Part of the petroleum engineer's training is practice in the application of fundamental sciences and basic knowledge to specific problems in his field. Such problems as the cementing of a well or the "killing" of a "wild" well are best learned, however, in industrial work rather than in an academic course.

The "work shop" or practical type of course, as used in some United States schools, has not been adopted by the University of Alberta, since it tends to flourish at the expense of instruction in the basic sciences and fundamentals.

NEED FOR PETROLEUM ENGINEERS

Developments in the oil industry during the past year have been outstanding, and will undoubtedly have an

important effect on the Canadian economy. The discovery and development of further oil reserves in Western Canada is the most significant of these.

The following table, as presented by the President of the Imperial Oil Company Limited, will indicate the marked increase in oil production since 1925:

CRUDE PETROLEUM OUTPUT

(in barrels of 35 gallons)

	1925	332,001
	1935	1,446,620
	1942	10,364,796
	1947	7,729,285
(estimated)	1948	12,500,000

The post-war activities mentioned at the beginning of this monograph leave no doubt that there is employment for petroleum engineers in Canada.

There is at present a shortage, particularly of men with four or five years' experience, and even of younger inexperienced men. Graduates with a broad fundamental training would appear to have opportunities at present (1949) and future prospects are favourable.

ORGANIZATIONS

The Chemical Institute of Canada, 18 Rideau Street, Ottawa, Canada.

The Engineering Institute of Canada, 2050 Mansfield Street, Montreal, P.Q.

APPENDIX

The Canadian Committee for Student Guidance in Science and Engineering is composed of representatives of The Engineering Institute of Canada, The Canadian Institute of Mining and Metallurgy, and The Chemical Institute of Canada. It co-ordinates the volunteer counselling services sponsored by the above named Institutes. The members of the Committee are:

G. R. Langley, M.E.I.C.—Chairman.

W. R. McClelland, M.C.I.M.—Secretary.

H. R. L. Streight, F.C.I.C.

The following is a list of Student Counsellors who are available to give advice and guidance to students contemplating a college course leading to any of the scientific or engineering professions. The body to which the counsellor belongs is indicated as follows:

E.I.C. —The Engineering Institute of Canada.

C.I.M. —The Canadian Institute of Mining and Metallurgy.

C.I.C. —The Chemical Institute of Canada.

C.S.F.E.—Canadian Society of Forest Engineers.

C.A.P. —Canadian Association of Physicists.

STUDENT COUNSELLORS

MARCH, 1949

NOVA SCOTIA

AMHERST	G. J. Medforth	Canada Electric Co.	E.I.C.
ANTIGONISH	Prof. J. C. Tobin	St. Francis Xavier University	C.A.P.
BRIDGEWATER	J. E. Clarke	N.S. Dept. of Highways	E.I.C.
DARTMOUTH	N. L. Shipley	Imperial Oil Co. Ltd., P.O. Box 490	C.I.C.
HALIFAX	Prof. A. E. Flynn	N.S. Technical College	E.I.C.
	G. J. Currie	N.S. Light & Power Co.	"
	Stewart Murray	Dir. of Guidance, Dept. of Education	
	H. Y. Haines	Dir. of Guidance, Bd. of School Comm'rs.	
	Dr. W. J. Archibald	Dalhousie University	C.A.P.
KENTVILLE	F. A. Herman	Experimental Station	C.I.C.
NEW GLASGOW	D. G. Dunbar	Pictou County Power Board	E.I.C.
LIVERPOOL	J. H. M. Jones	Mersey Paper Co.	"
SYDNEY	H. F. Arthur	Dominion Steel & Coal Co. Ltd.	"
TRURO	J. K. Godfrey	Truro Electric Commission	"
WOLFVILLE	G. D. Spence	Acadia University	"
	Prof. W. J. Noble	" "	C.A.P.
YARMOUTH	D. S. Wickwire	Town Engineer	E.I.C.

NEW BRUNSWICK

FREDERICTON	Dr. W. J. Wright	University of New Brunswick	C.I.M.
SACKVILLE	Dr. D. W. MacLaughlan	Box 91, Sackville, N.B.	C.I.C.
SAINT JOHN	A. G. P. McDermott	New Brunswick Telephone Co.	E.I.C.
	G. S. Lordley	Atlantic Sugar Refineries	C.I.C.

QUEBEC

ARVIDA	G. M. Mason	Aluminum Co. of Canada, 1 Radin Rd. W.	C.I.C.
	R. W. Kraft	Aluminum Co. of Canada	C.I.C.
	J. J. Fortin	" " "	E.I.C.
	R. A. Lemieux	925 Coulombe St.	"
	F. A. Dagg	111 Castner St.	"
ARNTFIELD	J. W. MacKenzie	Wasa Lake Gold Mines Ltd.	C.I.M.
ASBESTOS	G. K. Foster	Canadian Johns-Manville Co. Ltd.	C.I.M.
BOURLAMAQUE	J. G. L. McCrea	Sigma Mines Ltd.	C.I.M.
	J. C. Perry	Lamaque Mining Co. Ltd.	"
BROWNSBURG	J. B. Chalmers	Canadian Safety Fuse Co. Ltd.	C.I.M.
CHICOUTIMI	Rene Boulanger	Chicoutimi Pulp Co. Ltd.	E.I.C.
DOLBEAU	Claude Maxwell	Lake St. John Power & Paper Co.	"
DRUMMONDVILLE	John S. Hole	Canadian Celanese Ltd.	C.I.C.
GARDENVALE	R. C. Rowe	Canadian Mining Journal	C.I.M.
GRAND-MERE	F. W. Bradshaw	Consolidated Paper Corp. Ltd.	E.I.C.
	J. B. Sweeney	" " " "	"
KENOGAMI	Adam Cunningham	Price Bros. & Co. Ltd.	E.I.C.
KEWAGAMA	H. E. Sparks	Mgr. O'Brien Gold Mines Ltd.	C.I.M.
LA TUQUE	R. D. Packard	Brown Corporation	E.I.C.
MALARTIC	J. P. Millenbach	Mgr. Canadian Malartic Gold Mines Ltd.	C.I.M.
MONTREAL	G. B. Moxon	56 Chesterfield Ave., Westmount	E.I.C.
	W. H. Moore	Canadian Industries Limited	"
	Marc Boyer	Registrar, Corp. of Prof. Engineers	"
	E. A. Goodwin	Montreal Engineering Co. Ltd.	"
	H. C. Nourse	Bell Telephone Co.	"
	Prof. J. L. de Stein	McGill University	"
	Prof. R. de L. French	" "	"
	Prof. Henri Gaudefroy	Ecole Polytechnique de Montreal	"
	L. A. Duchastel	Shawinigan Water & Power Co.	"
	Jacques Benoit	Wallace & Tiernan Ltd.	"
	Prof. L. W. Bladon	McGill University	C.I.M.
	J. A. Dresser	715b Drummond Bldg.	"
	H. P. Dickey	722 Royal Bank Bldg.	"
	R. Hendricks	Consolidated Mining & Smelting Co.	"
	Dr. S. G. Lipsett	J. T. Donald & Co. Ltd., 1181 Guy St.	C.I.C.
	W. A. E. Pepler	Can. Pulp & Paper Assn., Sun Life Bldg.	C.S.F.E.
	F. S. McCarthy	Can. Industries Ltd.	C.I.C.
	P. L. Tremblay	Shell Oil Co. of Can. Ltd., 660 St. Catherine St. W.	C.I.C.
	W. R. McGlaughlin	4445 Walkley Ave.	C.I.C.
	E. E. Shaw	Can. International Paper Mills Ltd.	C.S.F.E.
	K. G. Fenson	3406 Atwater Ave.	C.S.F.E.
	J. O. Wilson	Anglo-Can. Pulp & Paper Mills Ltd.	C.S.F.E.
NORANDA	W. C. Corran		C.I.M.
	C. G. McLachlan	Noranda Mines Ltd.	"
QUEBEC	Prof. Rene Dupuis	Laval University	E.I.C.
	Dr. W. P. Percival	Dir. of Protestant Education	"
	Dr. Paul Gagnon	Laval University	"
	Philippe Methe	Directeur, Ecole Technique de Que.	"

QUEBEC (Continued)

QUEBEC	B. T. Denis	Quebec Department of Mines	C.I.M.
	G. W. Waddington	Laval University	"
	Prof. C. Ouellet	" "	C.I.C.
	F. Bonenfant	" "	C.A.P.
RIVERBEND	H. J. Barratt	Price Bros. & Co. Ltd.	E.I.C.
SHAWINIGAN FALLS	P. C. Telmosse	Shawinigan Water & Power Co.	E.I.C.
	A. H. Heatley	Shawinigan Chemicals Ltd.	"
	A. J. Abbott	" " "	C.I.C.
	J. P. Beaudry	Canadian Industries Limited	"
	G. Benson	Shawinigan Chemicals Ltd.	"
	E. L. Racicot	" " "	"
	E. R. Williams		C.I.M.
SHERBROOKE	C. B. Murphy	J. S. Mitchel & Co.	C.I.M.
SISCOE	R. G. Walsh	Mgr., Siscoe Gold Mines, Ltd.	C.I.M.
THETFORD MINES	C. H. McNaughton	Asbestos Corporation, Ltd.	C.I.M.
TROIS RIVIERES	J. F. Wickenden	Ameau Bldg.	E.I.C.
	H. C. Timmis	Consolidated Paper Corp. Ltd.	E.I.C.
	L. J. Morin	Consolidated Paper Corp. Ltd.	E.I.C.
VAL D'OR	G. S. Grant	Mine Ecole Provinciale	C.I.M.

ONTARIO

AMHERSTBURG	J. G. Turnbull	Brunner, Mond Canada, Limited	E.I.C.
ANGUS	R. S. Carman	Dept. of Lands & Forests	C.S.F.E.
BEARDMORE	G. A. McKay	Leitch Gold Mines, Ltd.	C.I.M.
BELLEVILLE	W. L. Langlois	287 Foster Avenue	E.I.C.
BRANTFORD	F. G. Haddow	Brantford Roofing Co., P.O. Box 810, Brantford	C.I.C.
	E. V. Gibbons	122 Elgin St.	C.I.C.
BROCKVILLE	T. W. Brackinreid	103 St. James St. East	C.I.M.
CAMPBELLFORD	F. A. Burgar	Box 200	E.I.C.
CARLETON PLACE	G. W. Motherwell	Carleton Place High School	C.I.C.
CENTRAL PATRICIA	D. B. Angus	Central Patricia Gold Mines, Ltd.	C.I.M.
CHATHAM	T. M. S. Kingston	City Manager	E.I.C.
	C. S. Evans	Union Gas Co. of Canada, Ltd.	C.I.M.
COBALT	A. A. Cole	Temiskaming Testing Laboratories	C.I.M.
CONISTON	F. G. Murphy	International Nickel Co. of Canada	C.I.M.
COPPER CLIFF	T. M. Gartz	International Nickel Co. of Canada	C.I.M.
CORNWALL	H. E. Mason	Howard Smith Paper Mills	C.I.C.
	N. I. Fattista	Courtald's (Canada) Ltd.	C.I.C.
	F. M. Robertson	Canadian Industries Limited	C.I.C.
	L. P. Stidwill	Box 1001	E.I.C.
CREIGHTON MINE	B. T. King	International Nickel Co. of Canada	C.I.M.
CREEMORE	G. F. Thompson	Creemore, Ont.	C.S.F.E.
DELORO	C. R. Whittemore	Deloro Smelting & Refining Co.	E.I.C.
DORSET	P. McEwen	Dept. of Lands & Forests, Dorset	C.S.F.E.
ELMIRA	E. M. Quinlan	Naugatuck Chemicals	C.I.C.
FALCONBRIDGE	J. Hunt	Falconbridge Nickel Mines Ltd.	C.I.M.
FORT WILLIAM	S. M. Smith	Canadian Westinghouse Co.	C.I.M.
FROOD MINE	A. E. O'Brien	International Nickel Co. of Canada	C.I.M.

ONTARIO (Continued)

GALT	W. A. Osbourne	Babcok-Wilcox & Goldie-McCulloch	E.I.C.
	I. C. Marritt	Dept. of Lands & Forests, Galt	C.S.F.E.
GERALDTON	A. E. Cave	Little Long Lac Gold Mines, Ltd.	C.I.M.
	J. M. Kilpatrick	MacLeod-Cockshutt Gold Mines Ltd.	C.I.M.
GRIMSBY	A. R. Globe	P. O. Box 567	C.I.M.
	F. D. Austin	Dept. of Highways	E.I.C.
GUELPH	Prof. W. C. Blackwood	Ontario Agricultural College	E.I.C.
	Prof. L. R. Bryant	" " "	C.I.C.
	H. Zimmerman	Hart Products	C.I.C.
HAILEYBURY	O. E. Walli	Provincial Institute of Mining	C.I.M.
HALEY	H. B. Megill	Dominion Magnesium Ltd.	C.I.M.
HAMILTON	Dr. A. H. Wingfield	High School of Commerce	E.I.C.
	G. M. Crossgrove	Bell Telephone Co. of Canada	E.I.C.
	W. J. W. Reid	Otis-Fensom Elevator Co. Limited	E.I.C.
	N. A. Eager	Burlington Steel Co. Ltd.	C.I.M.
	A. C. Graham	190 Prospect Ave. S.	C.I.C.
	G. L. T. Vollmer	1 Rosedale Ave., Bartonville	C.I.C.
	G. R. Smye	191 London St. S.	C.I.C.
	H. L. Fanshaw	120 St. Clair Ave.	C.I.C.
	K. A. J. Ramsay	P.O. Box 156	C.I.C.
HELEN MINE	C. M. Beck	Algoma Ore Properties Ltd.	C.I.M.
KINGSTON	Dean D. S. Ellis	Queen's University	E.I.C.
	M. G. Saunders	Aluminum Company of Canada	E.I.C.
	Prof. S. N. Graham	Queen's University	C.I.M.
	Dr. H. P. Godard	Aluminum Laboratories Ltd.	C.I.C.
	Dr. J. A. McRae	Queen's University	C.I.C.
	R. H. Rimmer	Aluminum Laboratories Ltd.	C.I.C.
	R. Ironside	Dye & Chemical Co. of Canada Ltd.	C.I.C.
	Dr. A. C. Plerves	Queen's University	C.I.C.
	Dr. Roy Spooner	Aluminum Co. of Canada	C.I.C.
	Dr. A. S. West	Dept. of Biology, Queen's University	C.S.F.E.
KIRKLAND LAKE	W. L. Redmond	Collegiate Institute	C.I.M.
KITCHENER	S. R. Shupe	City Engineer	E.I.C.
	R. K. Hymnen	Goodrich Rubber Co. Ltd.	C.I.C.
LEVACK	N. George	International Nickel Co. of Canada	C.I.M.
LINDSAY	A. D. Wheatley	Dept. of Lands & Forests	C.S.F.E.
LONDON	V. A. McKillop	Public Utilities Commission	E.I.C.
	Prof. G. H. Reavely	University of Western Ontario	C.I.M.
	Dr. J. Gunton	" " "	C.I.C.
	T. A. Faust	Yocum Faust Ltd.	C.I.C
	Prof. R. L. Allen	University of Western Ontario	C.A.P.
	P. J. Sandiford	" " "	C.A.P.
McKENZIE ISLAND	J. P. Nowlan	Cochenour Willans Gold Mines, Ltd.	C.I.M.
MADSEN	E. C. Crayston	Madsen Red Lake Gold Mines, Ltd.	C.I.M.
MURRAY MINE	R. Burford	International Nickel Co. of Canada	C.I.M.
NEW LISKEARD	R. H. Starr	Hydro-Electric Power Commission	C.I.M.
NIAGARA FALLS	A. W. F. McQueen	H. G. Acres & Co.	E.I.C.
	W. A. McBurney	P.O. Box 330	C.I.C.

ONTARIO (Continued)

NORTH BAY	J. G. A. Stevenson	56 Jane St. North	C.I.M.
ORILLIA	J. F. Turnbull	Gramshott Farm, R.R. 3, Orillia	C.S.F.E.
	T. G. Beament	Fahralloy Canada, Ltd., Barrie Rd.	C.I.M.
ORONO	G. M. Linton	Dept. of Lands & Forests	C.S.F.E.
OTTAWA	H. Beal	Dominion Forest Service, Motor Bldg.	C.S.F.E.
	Dr. L. E. Howlett	National Research Council	C.A.P.
	Dr. D. W. R. McKinley	" " "	"
	Dr. D. C. Rose	" " "	"
	Dr. P. Millman	Dominion Observatory	C.A.P.
	H. R. Welch	474 Bank St.	E.I.C.
	A. E. MacRae	56 Sparks St.	E.I.C.
	F. J. Alcock	Geological Survey of Canada	C.I.M.
	V. L. Eardley-Wilmot	Bureau of Mines, 40 Lydia St.	C.I.M.
	W. M. Goodwin	" " " " "	C.I.M.
	W. V. Morwick	Ottawa Technical High School	C.I.C.
	R. R. Rogers	Bureau of Mines	C.I.C.
	E. Brohman	Nepean High School, Westboro	C.I.C.
	Prof. J. Morton	Carleton College	C.I.C.
PAMOUR	J. H. Stovel, Jr.	Hallnor Mines, Ltd.	C.I.M.
PARRY SOUND	R. L. Snow	Dept. of Lands & Forests	C.S.F.E.
PETERBOROUGH	G. R. Langley	Canadian General Electric Co.	E.I.C.
	Roy H. Parsons	City Engineer	E.I.C.
	John W. Pierce	Room 64, Bank of Commerce Bldg.	E.I.C.
	J. L. McKeever		"
	B. Ottewell		"
	A. J. Bonney		"
PICKLE CROW	H. Monette	Pickle Crow Gold Mines, Ltd.	C.I.M.
PORT ARTHUR	R. B. Chandler	Public Utilities Commission	E.I.C.
PORT COLBORNE	R. C. McQuire	International Nickel Co. of Canada	C.I.M.
PORT HOPE	M. L. Pochon	P.O. Box 659	C.I.M.
PORT NELSON	T. S. Glover	Port Nelson	E.I.C.
RED LAKE	H. C. Young, Jr.	Campbell Red Lake Gold Mines Ltd.	C.I.M.
	M. R. Smith	P.O. Box 82	C.I.M.
ST. THOMAS	Warren C. Miller	City Engineer	E.I.C.
ST. WILLIAMS	F. S. Newman	Dept. of Lands & Forests	C.S.F.E.
SARNIA	E. K. Lewis	Imperial Oil Company	E.I.C.
	H. R. Emmerson	Polymer Corporation Ltd.	C.I.C.
	Dr. E. J. Buckler	510 George St.	C.I.C.
	F. F. Dyer		E.I.C.
	G. R. Henderson		"
	E. W. Dill		"
	A. E. Slater		"
	T. B. Doherty		"
	D. H. Welsh		"
SAULT STE. MARIE	LeRoy Brown	52 The Drive	E.I.C.
	G. W. MacLeod	A. C. Railway Terminal Bldg.	C.I.M.
SCHUMACHER	M. L. Urquhart	P.O. Box 274	C.I.M.
SOUTH PORCUPINE	C. P. Girdwood	Dome Mines, Ltd.	C.I.M.
STRATFORD	W. H. Riehl	Stratford	E.I.C.
	W. A. G. Thurston	Dept. of Lands & Forests	C.S.F.E.
SUDBURY	R. A. DeMorest	333 Homewood St.	C.I.M.

ONTARIO (Continued)

TILLSONBURG	C. V. Corless	Coniston Place	C.I.M.
TIMMINS	J. M. Douglas	19 Hemlock St.	C.I.M.
TORONTO	E. R. Graydon	Dominion Bridge Co., Shaw St.	E.I.C.
	E. M. Baird	1683 Kingston Rd.	E.I.C.
	G. L. Wallace	36 Evelyn Crescent	E.I.C.
	F. T. Simson	Canadian & General Finance Co.	E.I.C.
	L. M. Vardon	Toronto Transportation Commission	E.I.C.
	G. D. Maxwell	University of Toronto	E.I.C.
	M. B. Hastings	Powerlite Devices Ltd.	E.I.C.
	O. E. Johnston	Hydro-Electric Power Commission	E.I.C.
	John MacLellan	Hydro-Electric Power Commission	E.I.C.
	W. R. Carruthers	Bell Telephone Co.	E.I.C.
	J. W. Dyer	" " "	E.I.C.
	B. F. Moffat	Moffat's Limited, Weston	E.I.C.
	G. E. Lindsay	Exide Batteries of Canada, Ltd.	E.I.C.
	G. H. Rowat	Canadian S.K.F. Co.	E.I.C.
	K. C. Siddall	Carpenter Motor Supply Ltd.	E.I.C.
	L. B. Allan	Works Department, City Hall	E.I.C.
	H. L. Kennedy	Canadian Johns-Manville Co.	E.I.C.
	J. M. Hales	Canadian General Electric Co.	E.I.C.
	F. J. Comer	610 Federal Building	C.I.M.
	C. C. Huston	Room 1001, 85 Richmond St. W.	C.I.M.
	C. W. Knight	515 Jarvis Street	C.I.M.
	Grant Messer	Lever Bros. Ltd.	C.I.C.
	G. M. Gore	Central Technical School	C.I.C.
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Canadian Occupations
Monograph 20

CAREERS IN ENGINEERING

Revised 1960

Prepared
by the
Economics and Research Branch
of the
Department of Labour, Canada

HON. MICHAEL STARR
MINISTER

A. H. BROWN
DEPUTY MINISTER

FOREWORD

During recent years there has been a steadily increasing demand for Canadian occupational information. The demand comes from young people faced with the need of choosing an occupation and preparing for it; from parents, teachers and vocational guidance counsellors; from workers wishing to change their occupations; from employment service officers; from personnel directors and union officials; from prospective immigrants to Canada and from other quarters.

The CANADIAN OCCUPATIONS series of monographs is designed to help meet this demand. Each booklet describes, among other things, the nature of the occupation or groups of occupations, entrance and training requirements, working conditions and employment outlook.

The series has been prepared with the generous assistance of representatives of management, trade unions and professional associations. The co-operation of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour, and the Dominion Bureau of Statistics is gratefully acknowledged.

Occupational information tends to become dated as a result of changes in economic conditions, in industrial technology and in wage and salary structure. Revision of outdated publications is a regular feature of the series.

This booklet is a revision of the engineer monographs previously contained in *Careers in Natural Science and Engineering,* and was prepared for the Manpower Resources Division by Joseph P. Caccamo and William Allison, Chief of the Occupational Analysis Section. The help and co-operation of The Canadian Council of Professional Engineers, the Engineering Institute of Canada, and other organizations concerned with engineering is gratefully acknowledged.

W. R. DYMOND,
Director,
Economics and Research Branch,
Department of Labour.

September 1960

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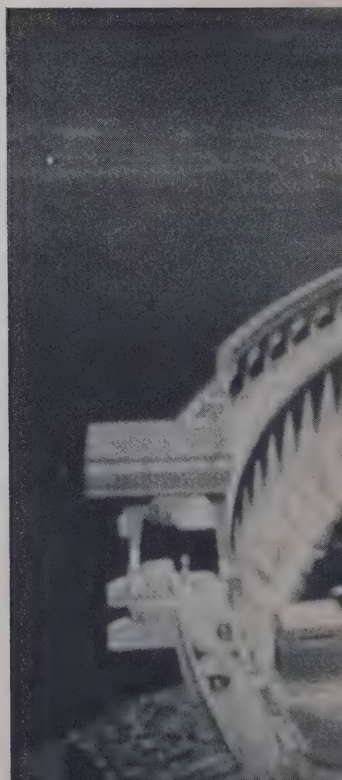

CAREERS IN ENGINEERING

Professional engineers are applied scientists who make practical use of the knowledge made available by science. Employing methods developed by practitioners of the art of engineering over the centuries, they utilize the materials and forces of nature and help organize the human effort necessary to produce the goods and services that satisfy human needs and wants. They are senior partners—often the leaders—in a team of workers that deals with the technical problems presented by any project making use of physical science.

Photo: NI

HISTORY AND IMPORTANCE

The creation of anything man-made—a road, a bridge, an automobile, a new chemical product, or even a better mousetrap—is essentially an engineering project in that the design, production and, in some cases, the marketing of the product is carried out or guided by engineers.

Because man is by nature a builder, creating for himself a more comfortable world out of the materials at hand, engineers have been with us for a very long time. Canals, roads, fortifications and monuments, many of them thousands of years old, are evidence of the modern engineer's heritage. In a highly complex and technological society such as we have today, scarcely any aspect of daily life is not affected, directly or indirectly, by the work of the engineer.

Engineering in Canada

Canada is a young country; many of her problems have been, and still are, those associated with growth and development. The very land which offered rich resources so abundantly also imposed difficulties of vast distances, rugged mountains, extreme winter conditions, and isolation from world markets.

From the beginning, the development of Canada has been a colossal undertaking in engineering, marked by projects that include spanning the continent with two railway systems and an all-weather motor vehicle highway; the completion of an inland water route that takes seagoing ships deep into the heart of the continent; completion of a multi-channel microwave communication system from coast to coast; exploitation of forest, mineral and water-power resources, and the establishment of a substantial manufacturing industry that is still growing rapidly.

Until the last quarter of the nineteenth century this work was carried out by engineers trained in Great Britain, the United States, and various European educational institutions. Courses in engineering were first offered at the University of New Brunswick, McGill University, *L'École Polytechnique* of the University of Montreal, and the University of Toronto. The first association of practising engineers in Canada was formed in 1887 as the Canadian Society of Civil Engineers, and in 1918 was renamed the Engineering Institute of Canada and broadened in scope

Photo: Ontario Hydro

Studying the scale model of the St. Lawrence Seaway and Power Project, one of the great engineering projects of our time.

to include all fields of engineering. The Canadian Council of Professional Engineers, formed in 1936, groups the provincial associations of professional engineers and represents the profession at the national level.

Engineers trained abroad have continued to seek and find careers in Canada, but facilities for training young Canadians have expanded rapidly, and at least 32 universities and colleges now offer one or more years of training leading to a degree in a variety of engineering fields. It is difficult to state the exact number of engineers in the country. Many people trained as engineers are engaged in work not ordinarily thought of as engineering, such as administration (see p. 29). The Department of Labour estimated that in 1951 there were about 35 thousand persons in Canada who had an engineering degree or its equivalent. By 1959, the estimate was between 45 and 50 thousand.

THE MAJOR FIELDS OF ENGINEERING

At one time, much engineering consisted of the construction of roads, canals, fortifications and machines for the waging of war. The Rideau Canal, built in 1826-32 by Col. John By, Royal Engineers, "to carry military traffic safely past American border waters", is one example. All other engineering of a non-military nature was therefore called "civil" engineering. With the increasing complexity of modern technology, "civil" engineers have tended to assume the name of the technological field in which they specialize, e.g., chemical, electrical, mechanical, etc. There is still some overlapping among the various fields, and no engineer can function in his own special field to the exclusion of all others. Indeed, the recent introduction of a four-year general engineering course without specialization may indicate the development of an engineering methodology that is applicable to all technical fields.

Photo: NFB

A civil engineer checks the progress of a new cement plant under construction.

CIVIL ENGINEERING

The term "civil engineer" now applies to those concerned with the creation of new or improved stationary structures of a "capital" rather than a "consumption" nature, and the surveying and reconstruction of geographic features of the earth.

Civil engineering includes four divisions:

Transportation—
highways, streets, railroads, elevated viaducts, and airports

Structural—
bridges, tunnels, subways, factory buildings, housing for power projects, electric transmission-line towers

Hydraulic—
dams, flood controls, irrigation systems, harbours, canals, reservoirs

Sanitary—
drinking water, drainage, sewage waste-disposal systems.

The structure of the earth is such an important factor in most civil engineering projects that *soil mechanics* has become a specialty for many civil engineers. Other specialties are *municipal engineering, community planning* and *traffic engineering. Surveying* is a separate and distinct field of work, although it is practised as an important part of all civil engineering.

The civil engineer's work often takes him outdoors, demands much active effort on the job, and places responsibility on him for great numbers of workers. Civil engineers are often "on the move". They are required on construction projects in remote areas and even in a settled area where a large project may keep them in one place for several years, eventually the project is completed and many of the engineers must move on. The vastness of Canada means that a great deal of travel is involved in this work. Obviously a civil engineer is more apt to enjoy his work if he is physically sturdy, likes to work with and direct others, and is prepared to work on the construction site and in various parts of Canada at least in the earlier years of his career.

The civil engineering field is so broad that many new specialties within it, including *structural, highway, hydraulic, railroad, sanitary,* and *public health engineering,* are crystallizing into separate fields, for which students may prepare particularly by some undergraduate concentration or a post-graduate degree.

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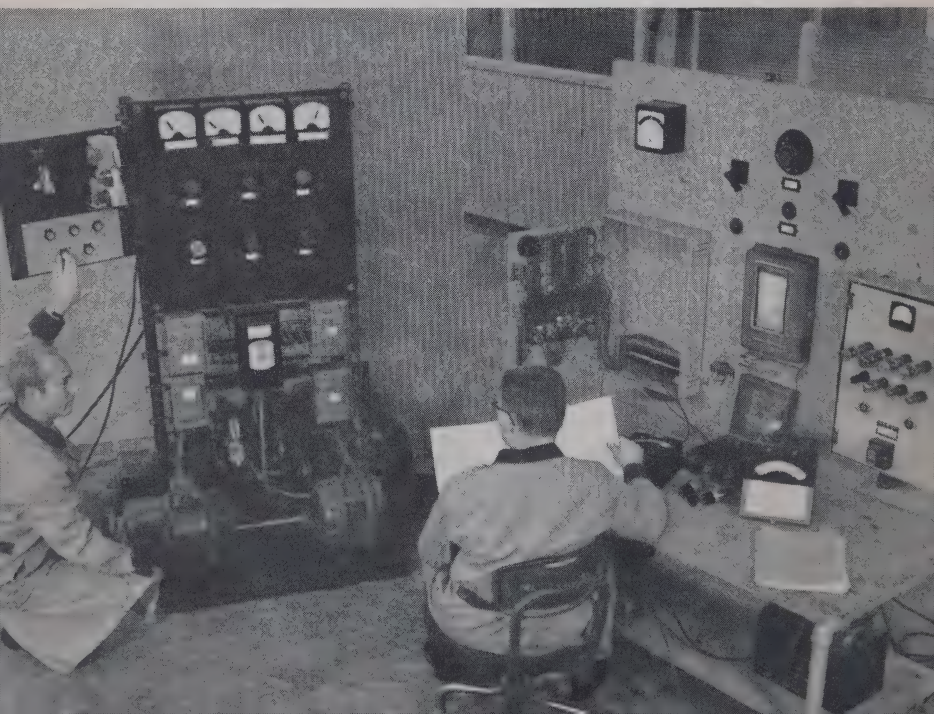
Forest Engineering

Civil engineers are the group chiefly engaged in the conservation and harvesting of Canada's forest crop, for which they are given the label *forest engineers*. Canada's forests and forest industries play a vital part in our national economy. Most of the forest engineers in Canada are employed by industrial concerns, particularly pulp and paper mills, and to a lesser extent, lumber companies. Engineering skill is needed to construct forestry roads, to improve streams for driving logs, to construct dams and bridges, and to solve many other problems associated with the transportation of logs. Forest engineers spend considerable time preparing maps and inventories of forest property and are responsible for a cutting schedule to provide continuity of supply of a crop that may take a century to mature.

Some universities offer courses in Forestry, which is a natural science course, and does not qualify for an engineering degree recognized by the provincial engineering associations.

This is a minature of an actual Canadian paper mill drive and control system. Engineers simulate actual working conditions to study operating problems.

Photo: Canadian General Electric



The field of the *electrical engineer* includes the systems, apparatus, and appliances whereby electricity is generated, transmitted, and controlled for light, heat, power, communication and electro-therapy.

Electrical engineering may be divided into four divisions:

Power—

generation, transmission and distribution of electrical energy; design, manufacture and operation of electrical apparatus and machinery (power transmission lines, transformers, electric sub-stations, industrial electric motors, generators, electro-chemical plants, and electrical measurement and control systems in other industrial products, e.g., aircraft, watercraft, electric railroad engines, automobiles); other applications in home, transportation and industry

Communications—

telephone, telegraph, radar, sound recording, radio, television, telephoto, teletype

Illumination—

lighting in homes, offices, plants, schools, streets, etc.

Electronics—

all electrical engineering that involves the passage of electricity through vacuum tubes, low-pressure gas tubes, and solid semi-conductors (transistors), providing controlled electron flow. This includes the measuring, switching, signalling and control by electronic impulses of manufacturing processes and apparatus of many types.

The manufacture of electronic components in Canada dates from the production of radio-receiver sets immediately after World War I. By 1923 several large companies were in this field and by 1937 over 80 per cent of radio receivers in Canada were Canadian-made. With the advent of World War II Canada was able to play a leading role in the development and manufacture of electronic equipment used by the Allied armies.

The Canadian electronics industry has continued to grow in the post-war period, despite heavy competition from other nations. Well over one hundred electronic companies produce all types of home-entertainment, commercial, industrial and military equipment in Canada today and every month sees new discoveries in this field that create further uses for electronic components and end-products.

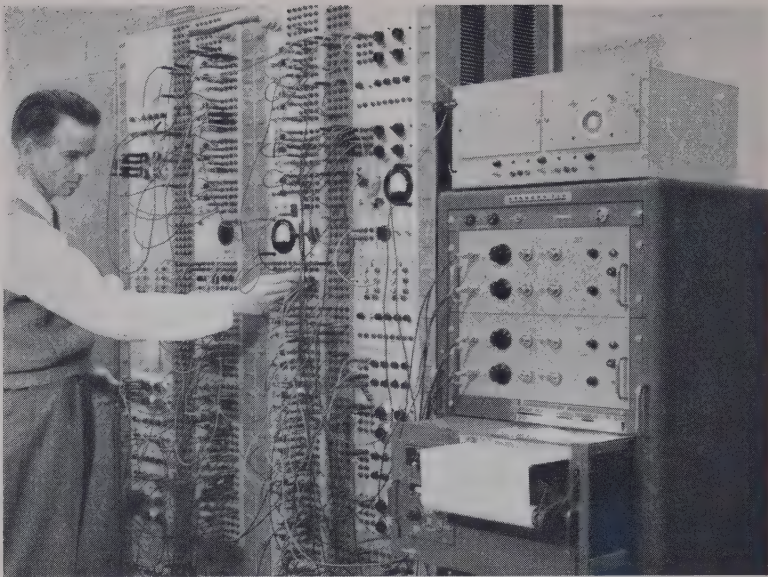


Photo: Canadian General Electric

An engineer sets up an electronic analogue computer to work out a mine-hoist experiment. Actual conditions simulated on this equipment can be studied and problems eliminated before the mine equipment is designed, manufactured or installed.

Canada has many major electrical utilities, and their operation requires large electrical engineering staffs. Water-power, steam and diesel engines are all used to generate electricity, but water-power outstrips the others by a very wide margin. This usually means that high-voltage transmission lines are required to bring the power to load centres. A nuclear-powered electrical generating plant is soon to be built in Ontario and others are planned.

Canadian industry is heavily electrified, and while manufacturers of electrical equipment have undoubtedly the greatest need for large staffs of electrical engineers, there are many other types of industry that also require electrical engineering personnel. The quantity of electrical power and the complexity of electrical systems used by modern paper, steel, and textile mills, chemical and automobile plants, mines, etc., are sufficiently great to require planning and operation by electrical engineers.

Mechanical engineers are especially qualified in the design and supervision of the manufacture, sale, and operation of machines and mechanisms that produce, transmit, or use power.

The mechanical field embraces four divisions:

Power-generating machines—
steam, diesel and other internal combustion, tidal and wind-power engines, and hydraulic or gas turbines

Power-transmission and materials-handling equipment—
conveyors, gears, shafting, and heat-transfer

Power-using motors and bodies—
machine tools, fans and other appliances, industrial furnaces, automobiles, locomotives, aircraft, and marine vessels

Heating and ventilating—
air-conditioning.

The scope of mechanical engineering is so wide and its services so universally needed as a basic part of all kinds of engineering projects, that it is not surprising to find these engineers in demand in a variety of industries in all parts of Canada. The development of Canadian heavy industry in metal fabrication, machinery and other fields since World War II has increased the need for mechanical engineers.

Since mechanical engineers work principally in manufacturing industries or on operation and maintenance work in power plants, they are likely to live in or near large population centres. They often direct and plan the work of others in the plant. Whether the product is electrical, chemical, or metallurgical in nature, mechanical engineers must work in close association with all the other engineering fields. They must become acquainted, sooner or later, with the various types of machine tools in order to have the proper layout of shop facilities ready for production.

Aeronautical engineers specialize in the application of mechanical engineering to the design, testing and construction of aircraft. More than half of these engineers are graduates in mechanical engineering, but graduates in engineering physics at the University of Toronto may then take a Master of Applied Science degree in Aeronautical Engineering and Aerophysics.

Industrial engineers specialize in the production function (see page 25), with emphasis on industrial and engineering analysis.

Training in this area is relatively new in Canada, and has been introduced only recently in the course of studies at the University of Toronto.

Engineering Applied to Agriculture

From the application of engineering technology to the many aspects of agriculture, there is emerging a new engineering expert: the *agricultural engineer*. He is an individual with a knowledge of plant, animal and soil science combined with training in some aspects of mechanical, chemical, electrical, or civil engineering. Depending on his technical background, his activities may be concerned with one or more of the following areas: farm machinery, farm structures, irrigation, soil conservation, land clearing, drainage and reclamation, farm electrification, and many others.

Persons with this combination of skills are employed by universities and the federal and provincial governments for research, teaching and extension work, and by private industries whose products and activities are closely related to or concerned with the agricultural industry.

The space age offers a new and exciting challenge to engineering.

Photo: Avro Aircraft Limited

CHEMICAL ENGINEERING

Chemical engineers are a good example of the engineer as a link between science and production. Their work involves adapting the laboratory process of the chemist to an efficient, low-cost, mass-produced commercial scale. It includes design, construction, and operation-management of plant and equipment that uses chemicals, rearranges the elements of nature to create improved or entirely new substances, and chemically tests products.

The field of chemical engineering cannot be clearly defined. The contribution of chemistry in a modern economy is all-pervasive; without it, few goods and services would be as effective as they are, and a great many owe their very being to chemistry. Rapidly expanding chemical developments in Canada are synthetic textiles, plastics, plywood, food processing, drugs, paints, and building materials. Because the use of chemistry is so widespread, opportunity for chemical engineers is correspondingly wide. Chemical engineers find employment in all industrial processes where chemistry plays a part, or where a knowledge of chemistry and engineering is valuable, as well as in the chemical industries proper.

The chemically oriented student should be sure that he wants to do engineering work before deciding on chemical engineering. If his interest is in testing and research rather than production, he should perhaps consider being a research scientist in chemistry.

MINING ENGINEERING

Mining engineers are concerned with the production of minerals, petroleum and natural gas, and other useful elements, that are mined from the earth. In Canada their broad field of operations includes exploration of unknown territory, development of promising deposits, supervision of surface and underground mining, milling and other primary treatment of ores, and mine-to-market operations.

The main mineral-products divisions are:

Metallics (e.g., iron)
Non-metallics (e.g., asbestos)
Fuels (e.g., petroleum)
Structural materials (e.g., gravel)

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It is not uncommon for a mining engineer to specialize in a particular mineral (e.g., coal), type of mineral (e.g., non-metals), or some aspect of mining (e.g., digging and conveying machinery or power and air-conditioning equipment).

Mineral wealth is one of Canada's main assets, exceeded in value of product only by forestry and agriculture. Abundant and varied mineral resources not only feed our expanding processing and manufacturing establishments but are also very important as a stock of materials and goods which the nation may exchange internationally for the many products wanted from other countries. Mineral output in Canada more than tripled during the period 1947-58; new deposits are discovered regularly, many new mines begin to be worked each year, yet only a small fraction of the expansive stretches of Canada have been investigated for mineral content.

The need to maintain competitive efficiency and safety and reduce hard physical labour has forced mines to become increasingly mechanized and complex. However, labour is still the larger part of mining costs, and most of the men to whom the mining engineer must provide direction have worked in mining all of their lives. No amount of academic training can take the place of working familiarity obtained in the mine. The mining engineer will likely be required to start at the bottom of the ladder as surveyor or sampler at the mine[1], but his academic qualifications and ability should enable him to move quickly upward through the operating ranks. To attain a position in the management ranks of the mining industry is a natural ambition of mining engineers; chances of success are good for a capable person, as most of the personnel in these posts are graduate mining engineers.

The mining engineer may find employment with companies that manufacture equipment, machines and engines used in mining. Government agencies do research in minerals and mining methods and employ mining engineers to administer the laws pertaining to mines. Mining engineers are considered well qualified to carry out some aspects of operations in the construction industry such as excavating and tunnelling.

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[1]See CANADIAN OCCUPATIONS Monograph 14, *Mining Occupations.*

Mining engineers in management positions often find themselves in a far broader field than even their operating responsibilities. It may include the organization and creation of a sizeable mining community and associated services and facilities at the site of an isolated bush camp.

Geological engineers are closely related to mining engineering, as they are concerned with field exploration, discovery and proving of mineral deposits. This includes the work of determining if the deposit is valuable enough to be mined commercially, and consideration of other factors such as accessibility, and available water and power supply.

Petroleum Engineering

Developments in the oil industry during recent years in Canada have been outstanding, and are having an important effect on the Canadian economy. The search for, discovery, and development of substantial oil reserves in Western Canada have so far been the most significant. Petroleum engineering is a division of mining engineering but has become a specialized type of work requiring considerably different training.

The petroleum engineer has to deal with any of a number of matters relating to the occurrence of petroleum: exploration methods, reservations and leases, field definition, well spacing, drilling equipment and methods, examining core samples, well finishing, well records, pumping, control of wells, design and construction of storage and transportation facilities, and general appraisal of oil and gas properties. Petroleum reservoir engineering is an area of specialization in which engineers are concerned with estimating the potential of oil and gas reservoirs for future production.

In the field of petroleum engineering, the distinction between petroleum *production* engineering and petroleum *refinery* engineering should be understood. Petroleum refining is an application of chemical engineering to the petroleum processing industry. Those interested in this phase should study the regular course of chemical engineering in which training in organic chemistry and in methods of separating and refining crude oils is included.

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Photo: NFB

Engineers in physical metallury watch the reheating of an ingot in the "soaking pit" preparatory to processing in the rolling mill.

Metallurgical engineering falls into four areas of work:

1. Extracting, concentrating, treating, and refining of metals.
2. Adapting metals and alloys to industrial use.
3. Fabricating and moulding metals and alloys into desired shapes for industrial use.
4. Studying earths, ores, metals, and alloys, their structure and constitution, physical and mechanical properties; separating, combining, or conditioning metals to obtain new qualities.

Metallurgical engineers devise and direct the construction and operation of apparatus, machinery and other equipment used to investigate the properties of metallic minerals and their useful elements, or to concentrate these substances and alter their form and qualities. If they are mainly involved in the concentration of the valuable part of a mineral into useable form and quantity, they

are in the division called *extractive* or *process* metallurgy. Engineers in the *physical* division convert the material into the final product.

The processing of metallic and non-metallic ores has been an important Canadian industry for many years and Canada now stands among the major world producers of nickel, aluminum, gold, magnesium and zinc, silver, copper, lead, asbestos, iron and uranium. Until 1939, operations in the Sudbury area in Ontario, Noranda and Thetford Mines in Quebec, and the Kootenay district of British Columbia accounted for most of the country's output. Since that time, the discovery and exploitation of many new deposits, expanding markets, and further technological improvements, have raised the mineral processing industry to the level of importance it enjoys in the Canadian economy today.

The metallurgical engineer's work is based on a knowledge of metals, chemistry and solid-state physics. The student must have good ability in chemistry and physics as well as mathematics, and be interested in metals and their uses. Metallurgical engineers have adapted themselves relatively easily to positions in related occupations commonly held by chemists, chemical engineers and physicists.

Ceramic engineering is a closely related but considerably specialized field and consists of the recovery and processing of non-metallic minerals. Methods and equipment used are similar to those for metals. The types of products common to the ceramic industry are structural clay or shale, bricks and blocks; porcelain enamel; refractories for lining furnaces against high temperatures; pottery and whitewares; glass; abrasives for grinding and finishing; cement, lime and gypsum.

ENGINEERING PHYSICS

The *engineering physicist* utilizes theory and knowledge that the physicist has discovered and formulated, by creating the machinery and processes that make it useful. Industrial applications of physics provide new and better goods and services, and discoveries in physics, when translated into practical methods and machines with the help of the engineer, are basic to advance in other natural sciences. The nature and properties of light, electricity, magnetism, heat, sound and matter, are within the immediate scope of the engineering physicist, and include atomic or nuclear physics, fluid mechanics, optics, acoustics, aeronautics, and geophysics.

Engineering physicists are usually employed to do fundamental research or developmental work toward the solution of a specific problem. They often deal with new ideas and unexplored areas, or problems that require a completely new approach. Machinery and equipment may have to be devised to carry out investigations which broaden man's knowledge of natural phenomena. In industry, engineering physicists are needed for development and production-line work by manufacturers whose products and production processes are highly technical. Various governmental and industrial laboratories engage engineering physicists for pure and applied engineering research.

The harnessing of nuclear energy for peaceful purposes presents many engineering problems.

Photo: Gilbert A. Milne & Co., Toronto

WHAT ENGINEERS DO

Broadly speaking, the professional engineer works with the forces and resources of nature to create new products and services for the satisfaction of human wants.

He is primarily interested in the inanimate, structural, mechanical aspect of things, keeping in mind, of course, their social and economic implications. In the sense that he is a scientist, he is a "physical scientist" working mainly with material phenomena. But while the scientist proper strives to enlarge mankind's consciousness of the universe and laws of cause and effect, the engineer is predominantly responsibile for putting the resources of science to work. He is more interested in operating power than in power itself, more in using things than in the state of things. To a greater degree than the scientists, the engineer must nearly always pay close attention to the human, economic and financial factors involved in projects undertaken.

The engineer does not usually work alone, but in the company of a team that includes other engineers, as well as technicians and tradesmen. Many individuals, with a combination of intelligence, better-than-average technical training, and experience, render valuable assistance to engineers as *technicians,* often doing work of a very complex nature that approaches professional engineering.

The engineer works in a team that includes other engineers, as well as technicians and tradesmen.

Photo: de Havilland Aircraft of Canada Limited.

Tradesmen—electricians, welders, machinists and mechanics—follow the techniques of their craft to carry out the practical aspects of fabrication and installation.

Students who feel after reading this monograph that engineering is not for them, though they want to do technical or mechanical work, might consider a skilled occupation as a technician or tradesman. Other monographs in the CANADIAN OCCUPATIONS series describe these in detail (see inside front cover). Such careers offer satisfying and well paid employment to individuals who are qualified and personally fitted for them. The full utilization of the engineer's creative power and knowledge depends greatly on the help of laboratory assistants, technicians, draughtsmen and tradesmen.

Functions

A professional engineer—whether in the chemical, mining, electrical or any other field—usually finds himself engaged in one or more of several activities or functions. Eventually, if he is fortunate, he will be able to concentrate on the particular activity which he feels best fitted to perform. Within each field there is a choice of function, although some activities are more characteristic of a particular field of engineering. For example, a fairly high percentage of civil engineers are employed in *construction,* which occupies much smaller groups of engineers in other fields.

Fundamental Research

Research is necessary for the advancement of engineering technique and use of scientific discovery. Fundamental research is usually exploratory and experimental; it may have no immediate goal except the hope of discovering a new technique, or it may seek to improve existing processes or techniques. Engineering research is carried on in universities and governmental agencies, and to an increasing extent in industry.

This type of work requires an engineer with exceptional ability in mathematics and thorough knowldege of the engineering technology in the field in which he specializes (e.g., chemistry in the case of a chemical engineer). Patience, persistence and a curiosity to experiment even after repeated failure are essential characteristics of the researcher.

Applied Research and Development

This is the adaptation of new knowledge or principles for the purpose of satisfying practical needs. It may involve the development and testing of prototypes of new products; new methods and techniques of analysis, production or construction; the use of new materials, or the solution of special problems. Applied research and development are more likely to bring the reward of tangible results than fundamental research.

Design Engineering

Designing consists of the application of established engineering principles to devise new components, products, equipment, structures or processes to meet functional requirements or performance specificatons. This will involve technical problems of bulk, weight, shape, durability and efficiency that must be solved with due regard to costs, and may be complicated by demands imposed by the artistic industrial designer who seeks to please style-conscious customers. The design engineer must maintain contact with the research and development staff and consult frequently with the engineers who will be responsible for planning and carrying out production.

Production and Production Planning

Whether the project is a single item, such as a structure, or the factory production of many identical items, planning is essential for the orderly arrangement of plant equipment, machine tools, purchase of materials, and organization of production workers, so that the project will move ahead according to a predetermined sequence and schedule.

Production engineers are in charge of routine production processes, plant layout, work methods and production scheduling. They may test the production periodically, keeping alert for ideas that may improve the efficiency of the production line or solving production problems that arise from time to time. Greater emphasis on production efficiency, including time-motion studies, elimination of fire and accident hazards, production cost records and control systems, production personnel training and, more recently, automatic systems, has made the *industrial engineer* an important member of the engineering team.

Thousands of engineering man-hours go into the design and construction of modern machines, vehicles and equipment. This is the draughting department of a large Canadian aircraft plant.

Photo: NF

Photo: NFB

Most engineering specifications are made up in the form of scale drawings. Draughting and blueprint reading are therefore important engineering skills.

Construction

This function applies mainly to those engineers who are in charge of on-site construction work. They direct and oversee the workmanship and building material that goes into the project, maintain the proper sequence of work and, in general, ensure that construction is carried out according to design and schedule.

Installation

Although installation of technical equipment is often carried out by technicians and tradesmen, it is necessary for engineers to supervise and direct installation of more complex equipment.

Operation and Maintenance

In the case of complex equipment these functions may be carried out under the direction of an engineer in charge of operation or maintenance. He will be responsible for seeing that proper operating conditions and performance are maintained, or arrange for regular maintenance, including a schedule of inspection, cleaning, parts replacement and overhaul.

Field Exploration

Although field exploration in Canada is chiefly identified with seeking out and proving mineral resources, it also includes soil testing at the site where large structures are to be erected; hydrographic survey for water power, irrigation or flood control; investigation of perma-frost depths, and other exploration of engineering

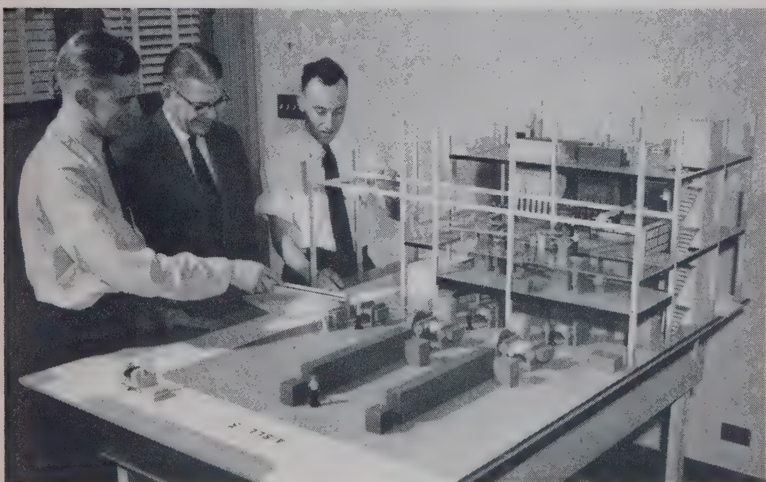

Photo: Graetz Bros. Limited, Montreal.

It is quite apparent that scale models are an important stage in most engineering projects. The layout for this rubber mill can be studied, and changed if necessary, before construction or operation starts.

importance. This work usually involves travel, often in winter, to distant and unsettled regions, by whatever means of transportation available. Use of eletromagnetic and seismic instruments, diamond drilling and examination of core samples is customary in this type of work.

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The functions outlined above are the ones associated with the purely *technical* aspects of engineering. They are seldom neatly separated, as the above arrangement might suggest. There are also a number of other functions closely related to or dependent on a professional knowledge of engineering.

Consulting

This is not a function in the same sense as those outlined above or below; rather, it is a type of employment in which engineers, in business for themselves or in partnership with other engineers, render a variety of professional engineering services to clients on

Consulting engineers provide a variety of professional engineering services on a fee basis.

Photo: NFB

a fee basis. Consulting offers opportunities for engineers, so inclined, to work on their own account rather than as employees. It gives them a measure of independence not enjoyed by employees but demands high technical competence and exceptional personal qualities. Consulting offers a wider scope for technical practice and demand for such services appears to be growing.

Technical Sales and Service

There is a growing need for sales representatives with engineering knowledge to handle technical products. Such people must, of course, have good sales ability, and an engineering background enables them to discuss intelligently the engineering principles and elements of their firm's products with the prospective buyer's engineering staff.

Teaching, Instructing and Extension Work

One of the requisites of a profession is that its members concern themselves with the transmission of their knowledge to those willing and able to learn. A great deal of teaching is done by engineers, formally and informally, on the job, but in Canada, primary responsibility for teaching fundamental engineering rests with the universities.

The professor of engineering at a university has advantages besides the satisfaction of passing on knowledge of engineering to students; he may also find this the best way to acquire time and facilities for research. Engineers are also well qualified to teach in institutes of technology, where technicians who assist engineers are trained. With teacher-training, engineers may teach the subjects that form the basis of their profession—mathematics, chemistry and physics—in secondary schools and colleges. (See CANADIAN OCCUPATIONS Monograph No. 44, *Teacher.*)

Administration (Management and Executive Posts)

Most of the routine, detailed, and physical labour in any engineering project is done by unskilled, skilled and semi-professional workers to whom the engineer must delegate authority and communicate instructions. Thus, almost every engineering position entails supervision of some staff.

Functional Specialization of Engineers
(in percentages)

—	Total	Civil	Forestry	Electrical	Mechanical	Chemical	Engineering Physics	Aeronautical	Mining	Petroleum	Metallurgical
	%	%	%	%	%	%	%	%	%	%	%
Research and Development	7	2	12	8	5	17	35	22	3	4	24
Designing and Draughting	10	11	1	10	12	7	1	12	2	5	1
Testing, Inspection and Lab. Serv.	2	2	1	2	1	4	3	5	2	2	6
Production Operation and Maintenance	23	27	17	19	22	24	5	12	28	36	18
Supervision and General Administration	36	36	52	37	34	31	15	35	49	39	34
Teaching, Instructing and Extension	2	2	3	2	2	3	25	1	1	—	2
Sales and Service, Marketing and Purchasing	9	3	4	12	14	8	1	3	3	4	9
Consulting	7	13	4	5	6	2	6	2	8	3	4
Other	4	4	6	5	4	4	9	8	4	7	2
Total	100	100	100	100	100	100	100	100	100	100	100

Note: Production includes Construction, Installation, Erection, Field Exploration, and Layout and Location.
Mechanical Engineering includes Industrial Engineering, and construction of watercraft, i.e., Naval Architecture.
Forest Engineering includes Silviculture.
Engineering-Physics includes Physics.
Other includes Finance, Accounting, Budgetary Control, Personnel, and Industrial Relations.

SOURCE: Economics and Research Branch, Dept. of Labour, Ottawa. Based on a representative one-third sample (7,157) of the engineers surveyed by the Department, 1959.

As business and industry become more and more concerned with modern technology and scientific management, the technical background of the engineer is of increasing value in administrative and executive positions. Advancement to these positions usually leads to duties with less and less technical content as the administrative function becomes increasingly important (see Levels E and F, p. 43) and many qualified engineers performing this function undoubtedly consider themselves primarily executives, rather than engineers.

PERSONAL QUALITIES NEEDED FOR SUCCESS

A prospective engineer should combine much curiosity regarding the how and why of Nature's laws and phenomena, with incentive to learn the answers. This will be demonstrated in practice in a strong interest and ability in secondary school physical sciences: mathematics, chemistry and physics.

In contrast to the scientist, who is concerned with knowledge for its own sake, the engineer as an *applied* scientist usually deals with practical problems. At the same time, the prospective engineer must be imaginative, because he will need to explore the universe of possibilities, and visualize what he seeks to create in terms of size, form, and function. He must be a "practical dreamer"—inquisitive, analytical, creative—yet always guided by cost. The engineer must produce things that are practicable as engineered creations, but they must also be economically feasible. Hence prospective engineers must not be averse to long and careful pondering of the inevitable financial aspects in every engineering project.

An engineer needs the faculty for working with other people, as his plans are often carried out through and by others. He needs qualities of leadership to convince and persuade, and to assume the role of responsibility that is customarily the engineer's. If a student does not want to be involved or bothered by supervisory duties or teamwork, perhaps one of the physical science fields would be a better choice.

The engineer must communicate with his assistants, employers, and colleagues, and produce plans, specifications and reports, using the written and spoken word. To some extent command of words is a natural talent, but clear, effective speaking and writing can be cultivated.

Like all pure and applied sciences, engineering at school and engineering on the job have this in common: much study, analysis, and thought is necessary. Not only must the working engineer exercise his mental capacity to meet new situations, he must also keep abreast of developments in engineering and the natural sciences. Engineering is extremely dynamic in that it is constantly improving its methods and knowledge in order to produce the innovations in goods and services which are characteristic of our economy.

Women in Engineering

It should be evident to anyone reading this monograph that there is no reason why a woman might not be a successful engineer. Nevertheless, although women may be found in every major field of engineering in Canada, the total number of women in the profession is extremely small.

On the whole, women tend to perform a narrower range of engineering duties than men; their more usual functions are research, testing, inspection, laboratory services, teaching, and certain production work. In other words, women are unlikely to be employed where a high degree of mechanical or manual activity is required.

Although engineering is traditionally a man's job, many engineering functions can be performed by women. This young lady, who made headlines by being the first female engineering graduate from McGill University in ten years, thinks there is no reason why more women shouldn't enter the field if they have the same interest and aptitude.

Photo: Montreal Gazette

No legal restrictions prevent women from entering the profession. However, certain aspects of engineering work tend to be regarded as less suitable for them than for men. Then, too, employers may hestitate to send women to remote locations or to put them into hazardous situations such as engineers sometimes meet.

It is apparent, therefore, that the woman engineer is likely to have difficult hurdles to take, but if she has the appropriate aptitudes and interests and is willing to persevere in the face of obstacles, she may be assured of a satisfying career.

PREPARATION AND TRAINING

Secondary School

High school is the place to begin preparing for an engineering career. The engineering curriculum is one of the heaviest, fullest schedules of lectures and assignments at university and calls for the best efforts even of good students. It is in high school that the prospective engineering student should form efficient study habits that will help carry him through the university course.

High school provides the groundwork of a good *general* education that includes English (or French), another modern language, and history, as well as mathematics and science.

Success in engineering will depend in great measure on a thorough training in the fundamental sciences: physics and chemistry, and a facility with the language of all science: mathematics. This is emphasized by the requirements for admission to the courses in engineering at Canadian universities. All stipulate a minimum standing of 60 per cent in final-year high school papers in algebra, geometry, trigonometry, physics and chemistry. Some require an average of 66 per cent.

University

Four years of study at a university faculty of engineering, following senior matriculation, is the customary education for engineers in Canada. The first year or two consists of general engineering principles; specialization as to field (e.g., civil, mechanical, electrical), is not covered until the third and fourth years. Some colleges that do not grant degrees in engineering

offer a preparatory one or two-year general course, following which the student transfers to a degree-granting institution for the final years of specialization. A representative curriculum of subjects (the same for all engineering fields) for the first and second year after senior matriculation would include the following:

Mathematics: algebra, geometry (analytical and descriptive), trigonometry, calculus, statistics

Natural Sciences: chemistry (organic and inorganic), physics (electricity, magnetism, heat, sound, light), geology

Introductory Engineering: mechanics, materials and their strength, engineering drawing, surveying (field work), mapping, engineering problems

Language: English composition (French in French-language institutions)

Social Sciences: modern world history, history of engineering, history of science, engineering law.

Most of these subjects will have been taken by the engineering student by the end of the second year at university. Third and fourth years, while continuing at a higher level some of the courses in the basic mathematics and sciences and general engineering

Surveying is a basic skill learned by all engineering students.

Photo: NFB

of first and second years, are composed largely of courses pertaining to the subject matter of the particular field selected by the student as a specialty. The student also has some flexibility in these last two years to prepare for certain specialties within the individual field, in being allowed to choose those he prefers among the optional courses offered. University calendars outline in detail the courses and options which are available for each field of specialization.

It is helpful for engineers in Canada to be bilingual. In French-language institutions, English-language text books are used for most of the courses in applied engineering and even several of the theoretical courses, along with texts printed in France, though all lectures are given in French. This is done to acquaint students with North American engineering methods which they will be in the main expected to practise (rather than French or European) and prepare them to co-operate and work with English-speaking engineers. More than half of the engineers surveyed by the Department of Labour stated that they speak both French and English. Engineers whose mother tongue is English find a knowledge of French useful since many of the people with whom they work, especially in Quebec, may be French-speaking.

The trend in engineering education is toward broadening the courses by including more of the humanities and social sciences, even to the extent at some universities of arranging for the Bachelor of Arts degree to be earned in an additional year after the four years for the Bachelor of Engineering. Study of such subjects as language, economics, modern world history, political science, philosophy of science occupies approximately six per cent of the total time of the four undergraduate years at Canadian universities.

First engineering degrees are called either Bachelor of Engineering or Bachelor of Applied Science, depending on the university usage. A notation is made on the diploma as to the field and optional specialties taken.

Fees and Living Expenses

The approximate range of fees, per year, for tuition is $300 to $700, depending on the educational institution. Living expenses must also be considered, especially if the student lives away from home. Living accommodation, including room, board, and laundry,

may cost from $350 to $850 per annual session, and does not include such items as transportation, text-books and supplies, clothes, entertainment, and other personal expenditures. University calendars usually give information on fees, type of accommodation available, and approximate cost.

Part of the expense of taking a university course can be met by earnings during summer vacations. There is also a steady increase in financial assistance for deserving students. Assistance is in the form of scholarships, bursaries, loan funds, etc., details of which may be obtained from your school principal, vocational guidance counsellor, or from university calendars. A publication of the Dominion Bureau of Statistics, *University Entrance Awards, 1960,* contains 1,200 separate entries describing scholarships and bursaries open to high school graduates wishing to attend Canadian universities and colleges.

Post-Graduate Study

Surveys made by the Economics and Research Branch of the Department of Labour indicate that while over 75 per cent of engineers surveyed have a bachelor degree in engineering less than ten per cent hold a master's degree, and not more than five per cent, doctorates. A master's degree may be earned in one year after a bachelor degree; a doctorate in two years after a master's. Approximately ten per cent of the engineers are not university graduates, but entries into the profession in the past ten years or more have nearly all been by university degree. The tendency is more and more not only to formal training in a higher educational institution as an absolute requirement, but there is also increasing demand for engineers with master's degrees or doctorates. Surveys by the National Research Council reveal that students enrolled in graduate engineering studies at Canadian universities have risen to 637 for 1959-60 from 206 for 1953-54—an increase of over 300 per cent in the last seven years!

Vacation and Part-time Employment

It is a generally accepted practice that, before the engineering degree is granted, a candidate is required to satisfy the college or faculty of engineering that he has completed a suitable amount

of practical work related to engineering. Requirements range from laboratory or field work at the university to summer vacation employment.

Training in Industry

Nearly all employers give newly graduated engineers a variety of assignments to help them get acquainted with the firm's operations. Most of the larger employers have long-term plans for future growth and encourage men with ambition by sponsoring company training courses, on salary, either on their premises or at nearby educational institutions. Trips to technical meetings are sponsored and committee and seminar activity is fostered, where young engineers can learn by contact with experts in their field. Many firms have excellent libraries and laboratories and make time available for research.

After graduation the young engineer still has a great deal to learn. Practical experience, often in conjunction with company training, adds to his competence as a professional engineer.

Photo: NFB

Qualifying by Private Study

It is possible for persons not holding an engineering degree to study privately, pass examinations set by the provincial associations of professional engineers and in that way qualify as professional engineers (P. Eng.). This takes many years to do by home study, with little recognition along the way, and only a small number have been successful. For further information, prospective candidates should consult the Registrar of the association in their province (see below for list of associations and addresses).

ENTRY INTO THE PROFESSION

The prime requisite for entry into the engineering profession is technical competence gained through adequate training and practical experience. Those wishing to use the title "Professional Engineer" (P. Eng.), and legally practise the engineering profession must be registered with their provincial association of professional engineers.

Registration as a professional engineer requires, as a minimum qualification, a bachelor degree in engineering or applied science from a recognized university or college and two years of practical engineering experience. The equivalent of a degree is the passing of examinations set or approved by the provincial associations. An engineering graduate who is in the process of attaining the required experience may use the title "Engineer-in-Training" or, in Quebec, "Junior Professional Engineer". Undergraduates in university, or persons planning to write the examinations set by an association, may be registered with the association as students. Details of individual requirements for each province may be obtained from the following:

The Canadian Council of Professional Engineers,
77 Metcalfe Street,
Ottawa, Ontario.

Association of Professional Engineers of the Province of British Columbia,
2210 West 12th Avenue,
Vancouver 9, B.C.

Association of Professional Engineers of Alberta,
123 Commercial Building,
10120 Jasper Avenue,
Edmonton, Alberta.

Association of Professional Engineers of Saskatchewan,
P.O. Box 101,
Regina, Sask.

Association of Professional Engineers of the Province of Manitoba,
Room 418, 265 Portage Ave.,
Winnipeg, Manitoba.

Association of Professional Engineers of the Province of Ontario,
236 Avenue Road,
Toronto, Ontario.

Corporation of Professional Engineers of Quebec,
1600 Pine Avenue West,
Montreal 25, P.Q.

Association of Professional Engineers of the Province of New Brunswick,
Room 134, Union Station,
Saint John, N.B.

Association of Professional Engineers of the Province of Nova Scotia,
P.O. Box 731,
Halifax, N.S.

Association of Professional Engineers of the Province of Prince Edward Island,
P.O. Box 151,
Charlottetown, P.E.I.

Association of Professional Engineers of the Province of Newfoundland,
P.O. Box H-183,
St. John's, Newfoundland.

Association of Professional Engineers of the Yukon Territory,
P.O. Box 812,
Whitehorse, Y.T.

Placement Assistance

The great majority of engineers work as salaried employees, according to the 1951 Census of Canada. In order to become established in the profession, prospective engineers must therefore locate an employer and satisfy him as to their personal qualifications and technical competence. Several sources of assistance are available to engineers and engineering students seeking employment.

Information about job opportunities can be secured from the Executive and Professional Division of the National Employment Service, which works in co-operation with placement officers in universities.

Recruiting campaigns at the universities were started by private industry and business during the recent engineer shortage, graduates often having a choice of two or three different jobs. This was an unusual condition not likely to last after the engineering supply and demand had become stabilized, but it is quite possible that employers will continue to seek out good engineering graduates at the universities.

Professional and technical associations also provide services designed to bring together prospective employers and engineers seeking employment. These include employment registers, published lists of vacancies, and employment desks at association meetings.

Daily and weekly newspapers, technical journals, and company brochures often list engineering opportunities.[1] Many students make contacts through summer employment which provide them with permanent positions upon graduation.

Governments at all levels—municipal, provincial and federal—are extensive employers of engineering services. Canada-wide competitions for engineering positions with the federal government are posted in public buildings such as post offices, local offices of the National Employment Service and the Civil Service Commission, and notices are carried regularly in the Canada Gazette and daily newspapers.

Engineers Trained Outside of Canada

Engineers who have received their training in another country and wish to practise in Canada as professional engineers must meet the legal requirements of the province where they intend to practise. These requirements vary somewhat from province to province, and exact information may be obtained from the Canadian Council of Professional Engineers or the Registrar of the appropriate provincial association. The provincial associations recognize a substantial number of engineering degrees from universities in all parts of the world. Individuals who do not hold such a degree are required to pass written examinations.

It is pointed out that in Canada, qualification for the engineering profession is not at all the same as certification for marine and stationary engineers.

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[1]See also *Engineering Careers in Canada,* published annually by the Engineering Institute of Canada.

WORKING CONDITIONS

Professional engineers work under widely varying conditions, depending on their function at a particular time and the field in which they specialize. They may be called from the relative quiet of the research laboratory and draughting room to the heat or noise of the factory shop; they may leave the comfort of the engineering office and travel perhaps hundreds of miles to take care of an emergency at a distant engineering project. Engineers are employed throughout Canada; the majority live and work in Ontario and Quebec, being concentrated in large urban centres. Many Canadian engineers are working on projects in foreign countries.

As leader of the engineering team, the engineer must take the responsibility for decisions involving the expenditure of large sums of money and affecting the lives and safety of workmen. Failure of a project during construction, or after its completion, may have costly and disastrous results.

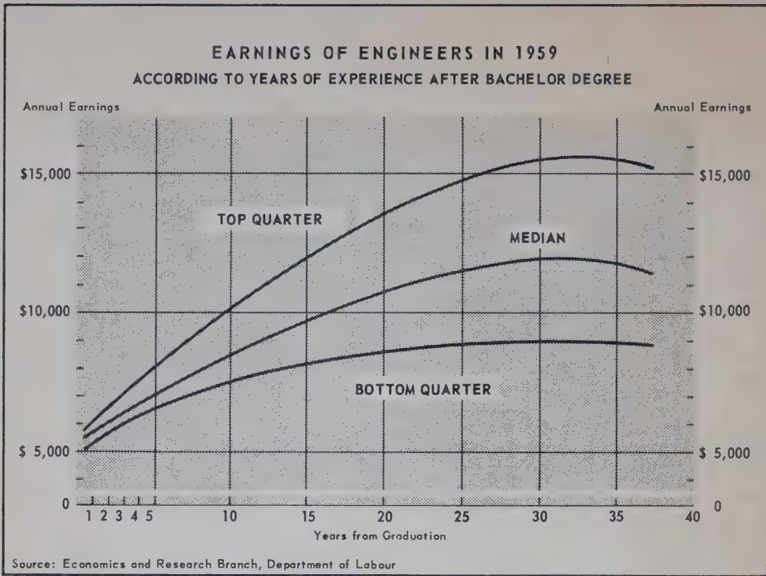
Engineers' working hours usually conform to plant or office hours where they are employed, but periods of emergency, difficult technical problems, or production deadlines to be met may involve long hours, sometimes under trying conditions. Engineers also have a professional responsibility to keep abreast of technical developments in their field by reading, conferring with engineering colleagues, or attending seminars.

EARNINGS AND ADVANCEMENT

The salaries and promotions of professional engineers reflect the individual's responsibilities, performance, and qualifications generally. Some companies place as much importance on seniority as on merit, but high technical achievement is usually well rewarded.

The most remunerative positions within engineering are in the consulting field, administration, and contracting. High salaries are paid for service in remote areas, probably a form of compensation for working and living conditions and travel away from home.

The careers of professional engineers follow such a wide variety of patterns, depending on individual abilities and circumstances, that no single pattern could be considered representative. A solution to the problem is found in the report of a survey conducted by



the Association of Professional Engineers of the Province of Ontario and the Corporation of Professional Engineers of Quebec[1]. The survey relates level of responsibility with salary and in so doing, provides some indication of the possible progress of an engineer's career. The following outline is abstracted from the report; a bachelor degree in engineering or applied science, or its equivalent, is prerequisite for each level.

Level A: The beginner, with little or no practical experience, is usually given duties of a routine nature in office, plant, field or laboratory, under close supervision. Median annual salary: $5,100.

Level B: Receives assignments of limited scope and complexity; assists more senior engineers in carrying out technical tasks requiring accuracy in calculation, completeness of data, and adherence to prescribed testing, analysis, design or computation methods. May give technical guidance to one or two junior engineers or technicians; must have at least two or three years engineering experience. Median annual salary: $6,100.

[1] Canadian Council of Professional Engineers, *Report on Salaries of Professional Engineers by Levels of Responsibility as of July 1, 1959,* available on request from the Council. (Salaries as reported for Ontario and Quebec. The survey covers approximately 110 firms, most of which are relatively large.)

Level C: Carries out responsible and varied engineering assignments, requiring general familiarity with a broad field of engineering. Problems usually solved by use of combinations or modifications of standard procedures, or methods developed in previous assignments. Participates in planning to achieve prescribed objectives. Work is not generally supervised in detail, but receives guidance on more difficult features of the assignment. A minimum of three to five years of related experience is required. Median annual salary: $7,100.

Level D: This is the first level of true professional supervision, *or* full specialization, and requires the application of mature engineering knowledge in planning and conducting projects. Assignments are received in terms of objectives, relative priorities and critical areas. Work is carried out within broad guide lines, but informed guidance is available. The engineer assigns and outlines work, advises on technical problems, makes recommendations concerning selection, training, rating and discipline of staff. A minimum of five to eight years in the field of specialization is necessary. Median annual salary: $8,300.

Level E: Usually requires knowledge of more than one field of engineering, *or* performance by an engineering specialist in a particular field. Participates in short and long-range planning and makes independent decisions on work methods and procedures. May supervise large groups containing both professional and non-professional staff or may exercise authority over a small group of highly qualified professional personnel engaged in complex technical applications. Outlines more difficult problems and methods of approach. Co-ordinates work programs and directs use of equipment and material, and makes recommendations regarding personnel. Minimum experience, nine to twelve years of engineering and/or administrative experience. Median annual salary: $10,140.

Level F: Usually responsible for an engineering administrative function, directing several professional and other groups engaged in interrelated engineering responsibilities, *or* as an engineering consultant recognized as an authority in an engineering field of major importance to the organization. Independently conceives programs and problems to be investigated, and participates in discussions determining basic operating policies. Reviews and

evaluates technical work; selects, schedules, and co-ordinates to attain objectives; as administrator, makes decisions concerning staff. Thirteen years or more of engineering experience, including responsible administrative duties, is required. Median annual salary: $12,220.

Having advanced beyond this level, the engineer operates with broad management authority, receiving virtually no technical guidance and control, limited only by general objectives and policies of the organization. He plans or approves projects requiring the expenditure of a considerable amount of money and manpower. He is responsible for long-range planning, co-ordination, and making specific and far-reaching management decisions. He is expected to possess a high degree of originality, skill and proficiency in the various broad phases of engineering application. This level is reached only after many years of authoritative engineering and administrative experience. Remuneration is usually commensurate with level of responsibility, ranging far beyond the salary reported for the previous level.

A word of caution is in order. An attractive salary is not the only consideration when seeking job satisfaction. The interest, challenge, or opportunities for professional development, offered by various types of employment, should be carefully investigated in terms of one's own personal aspirations and set of values.

OUTLOOK FOR ENGINEERS

Engineering activity varies from year to year, depending on economic conditions, causing short-term fluctuations in the demand for engineers. Vocational guidance counsellors and high school students are cautioned against basing long-range career decisions on short-term and often transitory employment conditions. There is a notable coincidence, for example, in the slackening demand for engineers in 1958 and 1959 and a corresponding decrease in engineering enrolments for these two years. The decision by a student in the final year of high school to become an engineer will not bear fruit for nearly five years, and this will mark but the beginning of a productive life that can be expected to last 40 to 50 years. To base such a decision on anything but a long-term outlook would hardly seem valid. There are serious limitations to

our ability to predict the distant future with accuracy, but broad generalizations can be made.

> *Basically, the engineering employment outlook depends on the growth potentiality of those industries which employ engineers in the largest numbers, and upon any trends in these industries which would make the functions performed by engineers more or less important.*

It is very significant that the recent and most exhaustive survey of Canada's economic future, carried out by the Royal Commission on Canada's Economic Prospects, found that most of the major employers of engineers (mining companies, manufacturing firms, construction contractors, and public utilities, including transportation and communication companies) are among those expected to be the fastest growing ones over the next two decades. In no case is their growth expected to be less than average. It can be concluded, therefore, that the industries which employ engineers in greatest numbers are also, by and large, those with the best future growth possibilities.

Apart from the growth of industries mentioned above, there is reason to believe that the demand for the services which engineers perform will increase even more rapidly. In today's world, economic growth is becoming more and more dependent on the practical use in the factory and in business, of as many as possible of the latest scientific discoveries. *This is exactly the task of the engineer and the technician.*

The wide range of functions performed by engineers has already been outlined, and it should be re-emphasized that employers do not hire engineers only for complex technical jobs. Many people with an engineering education find their way very quickly into jobs which, at least on the surface, do not seem to require much technical knowledge. Thus engineers are found in sales jobs, in market analysis work, and in a great variety of administrative and executive positions. What is known about the kinds of careers followed by engineers makes it very clear that management has found it can utilize them efficiently in a wide range of jobs, many of which have little technical content.

It is because of this that many firms hire engineers, usually new graduates, not primarily because of their suitability for a specific technical job, but rather because of their *potential qualities* which,

through training and experience with the firm, will enable them to make an important contribution in a variety of positions, including, in due course, management itself.

To summarize, future employment prospects for engineers in Canada are very good. Not only are the industries which employ most of them expected to be, by and large, fast-growing ones in the future, but also the needs of these industries for people with engineering education will increase more rapidly.

SOURCES OF ADDITIONAL INFORMATION AND GUIDANCE

The organizations of professional engineers welcome inquiries from students and persons with questions regarding the engineering profession. The office of the National Employment Service in your area can provide local information. University calendars, which may be obtained on request, outline academic requirements, detailed course content, financial aid, and tuition and living costs. Specific questions may be directed to the appropriate staff members.

Professional engineering associations help career-conscious students to get a glimpse of what engineering is like.

Photo: Victor Aziz—London.

Practising engineers possess a wealth of first-hand experience which they are usually willing to share with the interested student. Since this source provides a very individual point of view the student should, if at all possible, interview several engineers.

Almost any issue of the daily newspapers and financial publications contain some reference to engineering. Technical journals and books on engineering are available in public libraries. The student who is alert to information regarding engineering will notice the abundance of such items. In this way may be accumulated a knowledge of engineering in Canada and the world, which is available from no other source. Biographies of successful professional engineers often yield a personal insight of qualities that make a good engineer and the challenges and rewards that engineering has to offer.

Further Reading

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Opportunities for Graduates in Engineering and Physical Sciences. Civil Service Commission of Canada, Ottawa.

Engineering Careers in Canada. The Engineering Institute of Canada, Montreal.

A Professional Guide for Junior Engineers, 1949. The Engineering Institute of Canada, Montreal: 1949.

The Guidance Centre, Ontario College of Education, University of Toronto. Monographs, *Engineer—Professional*, 1960, *Chemical Engineer*, 1959, *Metallurgist—Metallurgical Engineer*, 1956.

The Engineering Profession, Association of Professional Engineers of the Province of Manitoba, Winnipeg; 1959.

APPENDIX

Other organizations with engineering membership:

The Engineering Institute of Canada,
2050 Mansfield Street,
Montreal, P.Q.

The Chemical Institute of Canada,
48 Rideau Street,
Ottawa, Ontario.

The Canadian Institute of Mining and Metallurgy,
906 Drummond Building,
Montreal 2, P.Q.

The Canadian Institute of Forestry,
10 Manor Road West,
Toronto 7, Ontario.

The Canadian Forestry Association,
4795 St. Catherine Street West,
Montreal, P.Q.

The Canadian Aeronautical Institute,
77 Metcalfe Street,
Ottawa, Ontario.

Association of Consulting Engineers of Canada,
Room 604,
620 Cathcart Street,
Montreal, P.Q.

Canadian Agricultural Engineering Society,
c/o Ontario Agricultural College,
Guelph, Ontario.

CANADIAN OCCUPATIONS FILMSTRIPS

The Department of Labour has prepared, to date, the following occupational filmstrips in collaboration with the National Film Board. A manual has been prepared as an accompaniment to each filmstrip. These may be purchased from the National Film Board, Box 6100, Montreal, or from any one of its regional offices.

Plumber, Pipefitter and Steamfitter
Careers in Engineering (revised in colour)
The Social Worker
Technical Occupations in Radio and Electronics
Bricklayer and Stone-Mason
Printing Trades
Careers in Natural Science (revised in colour)
Careers in Home Economics
Motor Vehicle Mechanic
Mining Occupations
Draughtsman
Careers in Construction
Machine Shop Occupations
Sheet-Metal Worker
Careers in Meteorology
Medical Laboratory Technologist (in colour)
Teacher (in colour)
Office Occupations (in colour)

* * * * *

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Ottawa, Canada

* * * * * *

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Plumber, Pipefitter and Steamfitter (b & w)
Careers in Engineering (colour)
The Social Worker (b & w)
Bricklayer and Stone-Mason (b & w)
Printing Trades (b & w)
Careers in Natural Science (colour)
Careers in Home Economics (b & w)
Motor Vehicle Mechanic (b & w)
Mining Occupations (b & w)
Draughtsmen (b & w)
Careers in Construction (b & w)
Machine Shop Occupations (b & w)
Sheet-Metal Worker (b & w)
Careers in Meteorology (b & w)
Medical Laboratory Technologist (colour)
Teacher (colour)
Office Occupations (colour)
Electrical and Electronic Occupations (colour)
Careers in Library Service (colour)
Electronic Computer Occupations (colour)

Canadian Occupations
Monograph 20

CAREERS IN ENGINEERING

Prepared
by the
Economics and Research Branch
of the
Department of Labour, Canada

HON. ALLAN J. MACEACHEN
MINISTER

GEORGE V. HAYTHORNE
DEPUTY MINISTER

First Edition 1953: Careers in Natural Science and Engineering
Revised 1960: Careers in Engineering
Revised 1964

Available by mail from the Queen's Printer, Ottawa,
and at the following Canadian Government bookshops:

OTTAWA
Daly Building, Corner Mackenzie and Rideau

TORONTO
Mackenzie Building, 36 Adelaide St. East

MONTREAL
Aeterna-Vie Building, 1182 St. Catherine St. West

or through your bookseller

A deposit copy of this publication is also available
for reference in public libraries across Canada

Price 25 Cents. Catalogue No. L43-2064

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Queen's Printer and Controller of Stationery
Ottawa, Canada
1964

Dept. of Labour
Reg. 20-1663

FOREWORD

During recent years there has been a steadily increasing demand for Canadian occupational information. The demand comes from young people faced with the need of choosing an occupation and preparing for it; from parents, teachers and vocational guidance counsellors; from workers wishing to change their occupations; from employment service officers; from personnel directors and union officials; from prospective immigrants to Canada and from other quarters.

The CANADIAN OCCUPATIONS series of monographs is designed to help meet this demand. Each booklet describes, among other things, the nature of the occupation or groups of occupations, entrance and training requirements, working conditions and employment outlook.

The series has been prepared with the generous assistance of representatives of management, trade unions and professional associations. The co-operation of the Unemployment Insurance Commission, the Technical and Vocational Training Branch of the Department of Labour, and the Dominion Bureau of Statistics is gratefully acknowledged.

Occupational information tends to become dated as a result of changes in economic conditions, in industrial technology and in wage and salary structure. Revision of outdated publications is a regular feature of the series.

This booklet is a revision of the engineer monographs previously contained in *Careers in Natural Science and Engineering*, and was prepared for the Manpower Resources Division by Joseph P. Caccamo and William Allison, Chief of the Occupational Analysis Section. The help and co-operation of The Canadian Council of Professional Engineers, the Engineering Institute of Canada, and other organizations concerned with engineering is gratefully acknowledged.

J. P. FRANCIS,
Director,
Economics and Research Branch,
Department of Labour.

January 1964

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CAREERS IN ENGINEERING

Professional engineers are applied scientists who make practical use of the knowledge made available by science. Employing methods developed by practitioners of the art of engineering over the centuries, they utilize the materials and forces of nature and help organize the human effort necessary to produce the goods and services that satisfy human needs and wants. They are senior partners—often the leaders—in a team of workers that deals with the technical problems presented by any project making use of physical science.

Photo: NFB

HISTORY AND IMPORTANCE

The creation of anything man-made—a road, a bridge, an automobile, a new chemical product, or even a better mousetrap— is essentially an engineering project in that the design, production and, in some cases, the marketing of the product is carried out or guided by engineers.

Because man is by nature a builder, creating for himself a more comfortable world out of the materials at hand, engineers have been with us for a very long time. Canals, roads, fortifications and monuments, many of them thousands of years old, are evidence of the modern engineer's heritage. In a highly complex and technological society such as we have today, scarcely any aspect of daily life is not affected, directly or indirectly, by the work of the engineer.

Engineering in Canada

Canada is a young country; many of her problems have been, and still are, those associated with growth and development. The very land which offered rich resources so abundantly also imposed difficulties of vast distances, rugged mountains, extreme winter conditions, and isolation from world markets.

From the beginning, the development of Canada has been a colossal undertaking in engineering, marked by projects that include spanning the continent with two railway systems and an all-weather motor vehicle highway; the completion of an inland water route that takes seagoing ships deep into the heart of the continent; completion of a multi-channel microwave communication system from coast to coast; exploitation of forest, mineral and water-power resources, and the establishment of a substantial manufacturing industry that is still growing rapidly.

Until the last quarter of the nineteenth century this work was carried out by engineers trained in Great Britain, the United States, and various European educational institutions. Courses in engineering were first offered at the University of New Brunswick, McGill University, *L'École Polytechnique* of the University of Montreal, and the University of Toronto. The first association of practising engineers in Canada was formed in 1887 as the Canadian Society of Civil Engineers, and in 1918 was renamed the Engineering Institute

Studying the scale model of the St. Lawrence Seaway and Power Project, one of the great engineering projects of our time.
Photo: Ontario Hydro

of Canada and broadened in scope to include all fields of engineering. The Canadian Council of Professional Engineers, formed in 1936, groups the provincial associations of professional engineers and represents the profession at the national level.

Engineers trained abroad have continued to seek and find careers in Canada, but facilities for training young Canadians have expanded rapidly, and at least 32 universities and colleges now offer one or more years of training leading to a degree in a variety of engineering fields. It is difficult to state the exact number of engineers in the country. Many people trained as engineers are engaged in work not ordinarily thought of as engineering, such as administration (see p. 30). The Department of Labour estimated that in 1951 there were about 35 thousand persons in Canada who had an engineering degree or its equivalent. By 1963, the estimate was nearly 50 thousand.

THE MAJOR FIELDS OF ENGINEERING

At one time, much engineering consisted of the construction of roads, canals, fortifications and machines for the waging of war. The Rideau Canal, built in 1826-32 by Col. John By, Royal Engineers, "to carry military traffic safely past American border waters", is one example. All other engineering of a non-military nature was therefore called "civil" engineering. With the increasing complexity of modern technology, "civil" engineers have tended to assume the name of the technological field in which they specialize, e.g., chemical, electrical, mechanical, etc. There is still some overlapping among the various fields, and no engineer can function in his own special field to the exclusion of all others.

A civil engineer checks the progress of a new cement plant under construction. Photo: NFB

CIVIL ENGINEERING

The term "civil engineer" now applies to those concerned with the creation of new or improved stationary structures of a "capital" rather than a "consumption" nature, and the surveying and reconstruction of geographic features of the earth.

Civil engineering includes four divisions:

Transportation—
 highways, streets, railroads, elevated viaducts, pipelines and airports

Structural—
 bridges, tunnels, subways, factory buildings, housing for power projects, electric transmission-line towers

Hydraulic—
 dams, flood controls, irrigation systems, harbours, canals, reservoirs

Sanitary—
 drinking water, drainage, sewage, waste-disposal systems.

The structure of the earth is such an important factor in most civil engineering projects that *soil mechanics* has become a specialty for many civil engineers. Other specialties are *municipal engineering*, *community planning* and *traffic engineering*. *Surveying* is a separate and distinct field of work, although it is practised as an important part of all civil engineering.

The civil engineer's work often takes him outdoors, demands much active effort on the job, and places responsibility on him for great numbers of workers. Civil engineers are often "on the move". They are required on construction projects in remote areas and even in a settled area where a large project may keep them in one place for several years, eventually the project is completed and many of the engineers must move on. The vastness of Canada means that a great deal of travel is involved in this work. Obviously a civil engineer is more apt to enjoy his work if he is physically sturdy, likes to work with and direct others, and is prepared to work on the construction site and in various parts of Canada at least in the earlier years of his career.

The civil engineering field is so broad that many new specialties within it, including *structural*, *highway*, *hydraulic*, *railroad*, *sanitary*, and *public health engineering*, are crystallizing into separate fields, for which students may prepare particularly by some undergraduate concentration or a post-graduate degree.

ELECTRICAL ENGINEERING

The field of the *electrical engineer* includes the systems, apparatus, and appliances whereby electricity is generated, transmitted, and controlled for light, heat, power, communication and electro-therapy.

Electrical engineering may be divided into four divisions:

Power—

generation, transmission and distribution of electrical energy; design, manufacture and operation of electrical apparatus and machinery (power transmission lines, transformers, electric sub-stations, industrial electric motors, generators, electro-chemical plants, and electrical measurement and control systems in other industrial products, e.g., aircraft, watercraft, electric railroad engines, automobiles); other applications in home, transportation and industry.

Communications—

telephone, telegraph, radar, sound recording, radio, television, telephoto, teletype

Illumination—

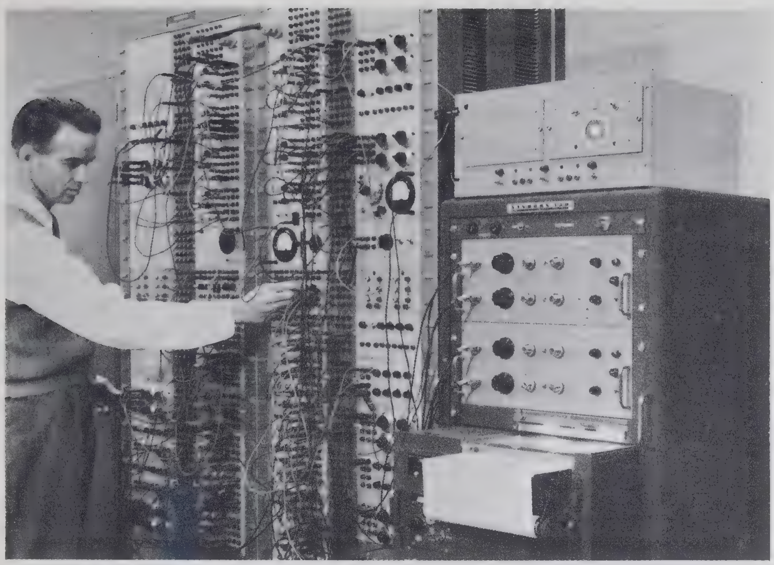
lighting in homes, offices, plants, schools, streets, etc.

Electronics—

all electrical engineering that involves the passage of electricity through vacuum tubes, low-pressure gas tubes, and solid semi-conductors (transistors), providing controlled electron flow. This includes the measuring, switching, signalling and control by electronic impulses of manufacturing processes and apparatus of many types.

The manufacture of electronic components in Canada dates from the production of radio-receiver sets immediately after World War I. By 1923 several large companies were in this field and by 1937 over 80 per cent of radio receivers in Canada were Canadian-made. With the advent of World War II Canada was able to play a leading role in the development and manufacture of electronic equipment used by the Allied armies.

The Canadian electronics industry has continued to grow in the post-war period, despite heavy competition from other nations. Well over one hundred electronic companies produce all types of home-entertainment, commercial, industrial and military equipment in Canada today and every month sees new discoveries in this field that create further uses for electronic components and end-products.



An engineer sets up an electronic analogue computer to work out a mine-hoist experiment. Actual conditions simulated on this equipment can be studied and problems eliminated before the mine equipment is designed, manufactured or installed.
Photo: Canadian General Electric

Canada has many major electrical utilities, and their operation requires large electrical engineering staffs. Water-power, steam and diesel engines are all used to generate electricity, but water-power outstrips the others by a very wide margin. This usually means that high-voltage transmission lines are required to bring the power to load centres. A nuclear-powered electrical generating plant has been built in Ontario and others are planned.

Canadian industry is heavily electrified, and while manufacturers of electrical equipment have undoubtedly the greatest need for large staffs of electrical engineers, there are many other types of industry that also require electrical engineering personnel. The quantity of electrical power and the complexity of electrical systems used by modern paper, steel, and textile mills, chemical and automobile plants, mines, etc., are sufficiently great to require planning and operation by electrical engineers.

MECHANICAL ENGINEERING

Mechanical engineers are especially qualified in the design and supervision of the manufacture, sale, and operation of machines and mechanisms that produce, transmit, or use power.

The mechanical field embraces four divisions:

Power-generating machines—
steam, diesel and other internal combustion, tidal and wind-power engines, and hydraulic or gas turbines

Power-transmission and materials-handling equipment—
conveyors, gears, shafting, and heat-transfer

Power-using motors and bodies—
machine tools, fans and other appliances, industrial furnaces, automobiles, locomotives, aircraft, and marine vessels

Heating and ventilating—
air-conditioning.

The scope of mechanical engineering is so wide and its services so universally needed as a basic part of all kinds of engineering projects, that it is not surprising to find these engineers in demand in a variety of industries in all parts of Canada. The development of Canadian heavy industry in metal fabrication, machinery and other fields since World War II has increased the need for mechanical engineers.

Since mechanical engineers work principally in manufacturing industries or on operation and maintenance work in power plants, they are likely to live in or near large population centres. They often direct and plan the work of others in the plant. Whether the product is electrical, chemical, or metallurgical in nature, mechanical engineers must work in close association with all the other engineering fields. They must become acquainted, sooner or later, with the various types of machine tools in order to have the proper layout of shop facilities ready for production.

Industrial engineers specialize in the production function (see page 26), with emphasis on industrial and engineering analysis. Training in this area is relatively new in Canada, and has been introduced only recently in the course of studies at the University of Toronto.

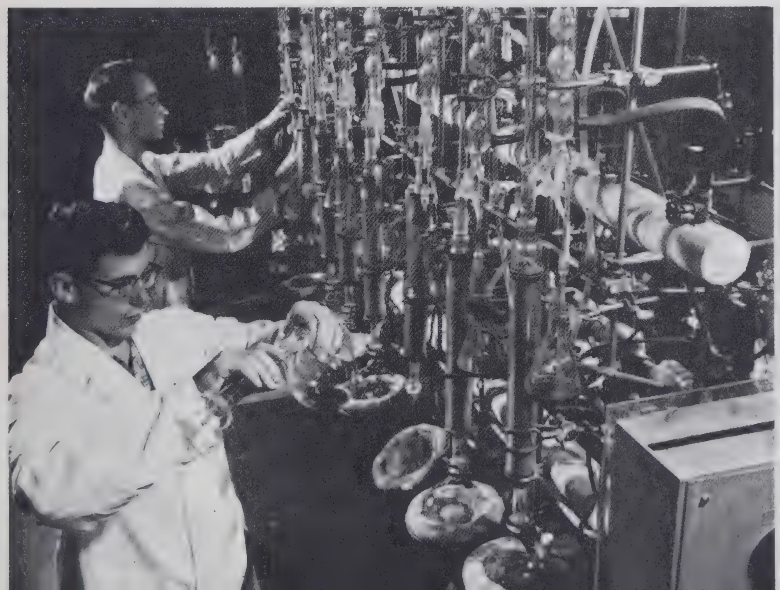
CHEMICAL ENGINEERING

Chemical engineers are a good example of the engineer as a link between science and production. Their work involves adapting the laboratory process of the chemist to an efficient, low-cost, mass-produced commercial scale. It includes design, construction, and operation-management of plant and equipment that uses chemicals, rearranges the elements of nature to create improved or entirely new substances, and chemically tests products.

The field of chemical engineering cannot be clearly defined. The contribution of chemistry in a modern economy is all-pervasive; without it, few goods and services would be as effective as they are, and a great many owe their very being to chemistry. Rapidly expanding chemical developments in Canada are synthetic textiles, plastics, plywood, food processing, drugs, paints, and building materials. Because the use of chemistry is so widespread, opportunity for chemical engineers is correspondingly wide. Chemical engineers find employment in all industrial processes where chemistry plays a part, or where a knowledge of chemistry and engineering is valuable, as well as in the chemical industries proper.

The chemically oriented student should be sure that he wants to do engineering work before deciding on chemical engineering. If his interest is in testing and research rather than production, he should perhaps consider being a research scientist in chemistry.

Photo: NFB by Malak



MINING ENGINEERING

Mining engineers are concerned with the production of minerals, petroleum and natural gas, and other useful elements, that are mined from the earth. In Canada their broad field of operations includes exploration of unknown territory, development of promising deposits, supervision of surface and underground mining, milling and other primary treatment of ores, and mine-to-market operations.

The main mineral-products divisions are:

Metallics (e.g., iron)

Non-metallics (e.g., asbestos)

Fuels (e.g., petroleum)

Structural materials (e.g., gravel)

It is not uncommon for a mining engineer to specialize in a particular mineral (e.g., coal), type of mineral (e.g., non-metals), or some aspect of mining (e.g., digging and conveying machinery or power and air-conditioning equipment).

Mineral wealth is one of Canada's main assets, exceeded in value of product only by forestry and agriculture. Abundant and varied mineral resources not only feed our expanding processing and manufacturing establishments but are also very important as a stock of materials and goods which the nation may exchange internationally for the many products wanted from other countries. Mineral output in Canada more than tripled during the period 1947-58; new deposits are discovered regularly, many new mines begin to be worked each year, yet only a small fraction of the expansive stretches of Canada have been investigated for mineral content.

The need to maintain competitive efficiency and safety and reduce hard physical labour has forced mines to become increasingly mechanized and complex. However, labour is still the larger part of mining costs, and most of the men to whom the mining engineer must provide direction have worked in mining all of their lives. No amount of academic training can take the place of working familiarity obtained in the mine. The mining engineer will likely be required to start at the bottom of the ladder as surveyor or sampler at the mine[1], but his academic qualifications and ability

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[1]See CANADIAN OCCUPATIONS Monograph 14, *Mining Occupations.*

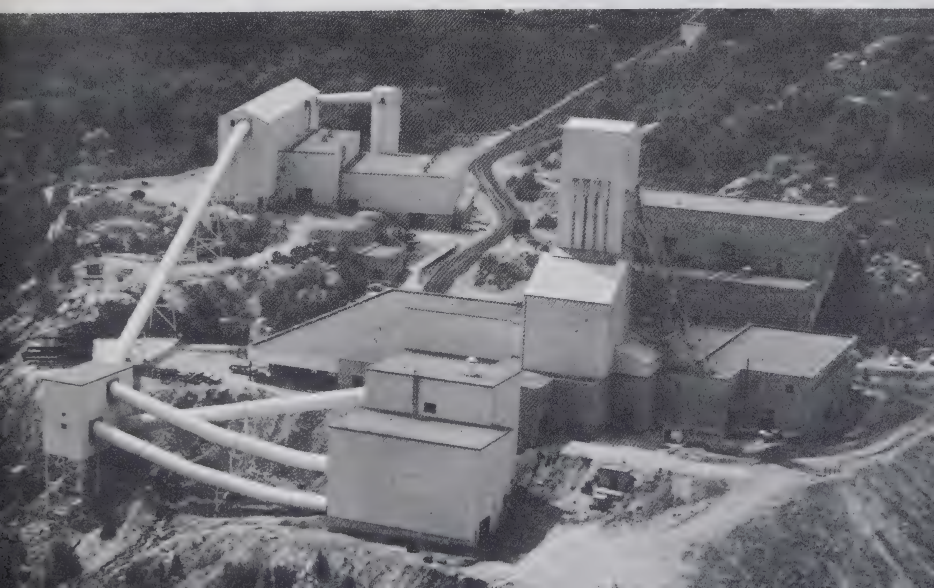
should enable him to move quickly upward through the operating ranks. To attain a position in the management ranks of the mining industry is a natural ambition of mining engineers; chances of success are good for a capable person, as most of the personnel in these posts are graduate mining engineers.

The mining engineer may find employment with companies that manufacture equipment, machines and engines used in mining. Government agencies do research in minerals and mining methods and employ mining engineers to administer the laws pertaining to mines. Mining engineers are considered well qualified to carry out some aspects of operations in the construction industry such as excavating and tunnelling.

Mining engineers in management positions often find themselves in a far broader field than even their operating responsibilities. It may include the organization and creation of a sizeable mining community and associated services and facilities at the site of an isolated bush camp.

Geological engineers are closely related to mining engineering, as they are concerned with field exploration, discovery and proving of mineral deposits. This includes the work of determining if the deposit is valuable enough to be mined commercially, and consideration of other factors such as accessibility, and available water and power supply.

Photo: Dept. of Mines and Technical Surveys



PETROLEUM ENGINEERING

Developments in the oil industry during recent years in Canada have been outstanding, and are having an important effect on the Canadian economy. The search for, discovery, and development of substantial oil reserves in Western Canada have so far been the most significant. Petroleum engineering is a division of mining engineering but has become a specialized type of work requiring considerably different training.

The *petroleum engineer* has to deal with any of a number of matters relating to the occurrence of petroleum: exploration methods, reservations and leases, field definition, well spacing, drilling equipment and methods, examining core samples, well finishing, well records, pumping, control of wells, design and construction of storage and transportation facilities, and general appraisal of oil and gas properties. Petroleum reservoir engineering is an area of specialization in which engineers are concerned with estimating the potential of oil and gas reservoirs for future production.

In the field of petroleum engineering, the distinction between petroleum *production* engineering and petroleum *refinery* engineering should be understood. Petroleum refining is an application of chemical engineering to the petroleum processing industry. Those interested in this phase should study the regular course of chemical engineering in which training in organic chemistry and in methods of separating and refining crude oils is included.

Photo: NFB by B. Beaver

Aeronautical engineers specialize in the design, testing and construction of aircraft and, more recently, guided missiles, rockets, satellites and space craft.

For a country of relatively small population, Canada has made some substantial contributions to the field of aeronautics and space technology. The first major contribution was the aerodynamic research work in a wind tunnel built in New Brunswick by W. R. Turnbull even before the Wright brothers made their first flight in 1903. In the design and production of jet aero engines, airframes and armament systems, in the high quality of its engineering staffs, and in the production records it has achieved through the years, Canada has won world recognition. Work in aeronautics has been extended to space technology with the development of the *Black Brant* high-altitude research rocket and the *Alouette* satellite, both of which have performed with outstanding success.

Modern aeronautics is based largely on mechanical engineering and engineering physics with specialization in aerodynamics. Optional courses in this subject are offered at the University of British Columbia, Laval University, and McGill University. The University of Toronto offers both undergraduate and graduate studies in Aeronautical/Astronautical Engineering in connection with its course in Engineering Physics.

The space age offers a new and exciting challenge to engineering.
Photo: Avro Aircraft Limited

AGRICULTURAL ENGINEERING

From the application of engineering technology to agriculture there is emerging a new expert: the *agricultural engineer.* He combines a knowledge of agricultural science with training in some aspects of mechanical, chemical, electrical or civil engineering. Depending on his technical background, his work may be concerned with one or more of the following areas: farm machinery; farm structures; irrigation; soil conservation; land clearing, drainage and reclamation; farm electrification; and many others.

Persons with this combination of science and engineering technology are employed by universities and government agencies for research, teaching and extension work, and by private industries which handle agricultural products or service the agricultural industry.

University training varies. It is usually obtained in a faculty of agriculture and may lead to the degree of Bachelor of Science with a major in Agricultural Engineering, or to a Bachelor degree in Agricultural Engineering. Prospective students should check carefully with the university registrar to make sure the courses offered are appropriate for their vocational plans to become a professional engineer.

FOREST ENGINEERING

Canada's forests and forest industries play a vital part in our national economy. Total forested land amounts to more than 1,700,000 square miles, of which nearly 60 per cent contains marketable timber.

Forest Engineers are chiefly engaged in the conservation and harvesting of the forest crop. Engineering skill is needed to construct forestry roads, to improve streams for driving logs, to construct dams and bridges, and to solve many other problems associated with cutting, extracting and transporting logs from forests to markets. Forest engineers spend considerable time preparing maps and inventories of forest property and are responsible for developing a cutting schedule to provide continuity of supply of a crop that may take a century to mature. Increasing emphasis on scientific management, conservation and utilization will expand the future role of the engineer in Canada's forest industry.

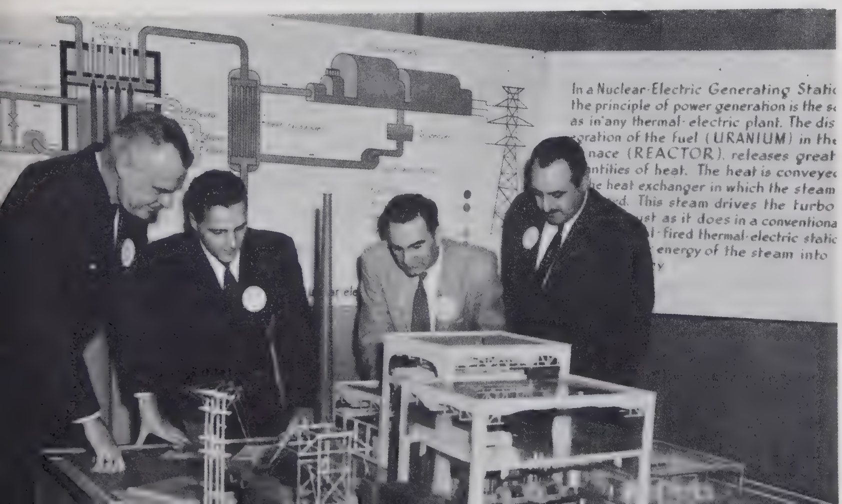
Distinction between forest engineering and forest science is not always clear cut, and students should examine their basic interests in the light of the qualities needed for success, outlined on page 32, if choosing between a course in forestry as a scientist or as an engineer. They should also make certain that the university they select offers the forestry course consistent with their interests.

ENGINEERING PHYSICS

The *engineering physicist* utilizes theory and knowledge that the physicist has discovered and formulated, by creating the machinery and processes that make it useful. Industrial applications of physics provide new and better goods and services, and discoveries in physics, when translated into practical methods and machines with the help of the engineer, are basic to advance in other natural sciences. The nature and properties of light, electricity, magnetism, heat, sound and matter, are within the immediate scope of the engineering physicist, and include atomic or nuclear physics, fluid mechanics, optics, acoustics, aeronautics, and geophysics.

Engineering physicists are usually employed to do fundamental research or developmental work toward the solution of a specific problem. They often deal with new ideas and unexplored areas, or problems that require a completely new approach. Machinery and equipment may have to be devised to carry out investigations which broaden man's knowledge of natural phenomena. In industry, engineering physicists are needed for development and production-line work by manufacturers whose products and production processes are highly technical. Various governmental and industrial laboratories engage engineering physicists for pure and applied engineering research.

The harnessing of nuclear energy for peaceful purposes presents many engineering problems. Photo: Gilbert A. Milne & Co., Toronto



Engineers in physical metallurgy watch the reheating of an ingot in the "soaking pit" preparatory to processing in the rolling mill. Photo: NFB

Metallurgical engineering falls into four areas of work:

1. Extracting, concentrating, treating, and refining of metals.
2. Adapting metals and alloys to industrial use.
3. Fabricating and moulding metals and alloys into desired shapes for industrial use.
4. Studying earths, ores, metals, and alloys, their structure and constitution, physical and mechanical properties; separating, combining, or conditioning metals to obtain new qualities.

Metallurgical engineers devise and direct the construction and operation of apparatus, machinery and other equipment used to investigate the properties of metallic minerals and their useful elements, or to concentrate these substances and alter their form and qualities. If they are mainly involved in the concentration of the valuable part of a mineral into useable form and quantity, they

are in the division called *extractive* or *process* metallurgy. Engineers in the *physical* division convert the material into the final product.

The processing of metallic and non-metallic ores has been an important Canadian industry for many years and Canada now stands among the major world producers of nickel, aluminum, gold, magnesium and zinc, silver, copper, lead, asbestos, iron and uranium. Until 1939, operations in the Sudbury area in Ontario, Noranda and Thetford Mines in Quebec, and the Kootenay district of British Columbia accounted for most of the country's output. Since that time, the discovery and exploitation of many new deposits, expanding markets, and further technological improvements, have raised the mineral processing industry to the level of importance it enjoys in the Canadian economy today.

The metallurgical engineer's work is based on a knowledge of metals, chemistry and solid-state physics. The student must have good ability in chemistry and physics as well as mathematics, and be interested in metals and their uses. Metallurgical engineers have adapted themselves relatively easily to positions in related occupations commonly held by chemists, chemical engineers and physicists.

Ceramic engineering is a closely related but considerably specialized field and consists of the recovery and processing of non-metallic minerals. Methods and equipment used are similar to those for metals. The types of products common to the ceramic industry are structural clay or shale, bricks and blocks; porcelain enamel; refractories for lining furnaces against high temperatures; pottery and whitewares; glass; abrasives for grinding and finishing; cement, lime and gypsum.

WHAT ENGINEERS DO

Broadly speaking, the professional engineer works with the forces and resources of nature to create new products and services for the satisfaction of human wants.

He is primarily interested in the inanimate, structural, mechanical aspect of things, keeping in mind, of course, their social and economic implications. In the sense that he is a scientist, he is a "physical scientist" working mainly with material phenomena. But while the scientist proper strives to enlarge mankind's consciousness of the universe and laws of cause and effect, the engineer is predominantly responsible for putting the resources of science to work. He is more interested in operating power than in power itself, more in using things than in the state of things. To a greater degree than the scientists, the engineer must nearly always pay close attention to the human, economic and financial factors involved in projects undertaken.

The engineer does not usually work alone, but in the company of a team that includes other engineers, as well as technicians and tradesmen. Many individuals, with a combination of intelligence, better-than-average technical training, and experience, render valuable assistance to engineers as *technicians*[1], often doing work of a very complex nature that approaches professional engineering.

1. For further information, see CANADIAN OCCUPATIONS Monograph No. 48 *Technicians in Science and Engineering*.

The engineer works in a team that includes other engineers, as well as technicians and tradesmen. Photo: de Havilland Aircraft of Canada Limited.

Tradesmen—electricians, welders, machinists and mechanics—follow the techniques of their craft to carry out the practical aspects of fabrication and installation.

Students who feel after reading this monograph that engineering is not for them, though they want to do technical or mechanical work, might consider a skilled occupation as a technician or tradesman. Other monographs in the CANADIAN OCCUPATIONS series describe these in detail (see inside front cover). Such careers offer satisfying and well paid employment to individuals who are qualified and personally fitted for them. The full utilization of the engineer's creative power and knowledge depends greatly on the help of laboratory assistants, technicians, draftsmen and tradesmen.

Functions

A professional engineer—whether in the chemical, mining, electrical or any other field—usually finds himself engaged in one or more of several activities or functions. Eventually, if he is fortunate, he will be able to concentrate on the particular activity which he feels best fitted to perform. Within each field there is a choice of function, although some activities are more characteristic of a particular field of engineering. For example, a fairly high percentage of civil engineers are employed in *construction*, which occupies much smaller groups of engineers in other fields. A chart on page 31 shows how the following functions are distributed among the various engineering fields.

Research and Development

Research is necessary for the advancement of engineering technique and use of scientific discovery. Fundamental research is usually exploratory and experimental; it may have no immediate goal except the hope of discovering a new technique, or it may seek to improve existing processes or techniques. Engineering research is carried on in universities and governmental agencies, and to an increasing extent in industry.

This type of work requires an engineer with exceptional ability in mathematics and thorough knowledge of the engineering technology in the field in which he specializes (e.g., chemistry in the case of a chemical engineer). Patience, persistence and a curiosity to experiment even after repeated failure are essential characteristics of the researcher.

Applied research and development is the adaptation of new knowledge or principles for the purpose of satisfying practical needs. It may involve the development and testing of prototypes of new products; new methods and techniques of analysis, production or construction; the use of new materials, or the solution of special problems. Applied research and development are more likely to bring the reward of tangible results than fundamental research.

Design Engineering

Designing consists of the application of established engineering principles to devise new components, products, equipment, structures or processes to meet functional requirements or performance specifications. This will involve technical problems of bulk, weight, shape, durability and efficiency that must be solved with due regard to costs, and may be complicated by demands imposed by the artistic industrial designer who seeks to please style-conscious customers. The design engineer must maintain contact with the research and development staff and consult frequently with the engineers who will be responsible for planning and carrying out production.

Production, Operation, Maintenance

Whether the project is a single item, such as a structure, or the factory production of many identical items, planning is essential for the orderly arrangement of plant equipment, machine tools, purchase of materials, and organization of production workers, so that the project will move ahead according to a predetermined sequence and schedule.

Production engineers are in charge of routine production processes, plant layout, work methods and production scheduling. They may test the production periodically, keeping alert for ideas that may improve the efficiency of the production line or solving production problems that arise from time to time. Greater emphasis on production efficiency, including time-motion studies, elimination of fire and accident hazards, production cost records and control systems, production personnel training and, more recently, automatic systems, has made the *industrial engineer* an important member of the engineering team.

Thousands of engineering man-hours go into the design and construction of modern machines, vehicles and equipment. This is the drafting department of a large Canadian aircraft plant.

Most engineering specifications are made up in the form of scale drawings. Drafting and blueprint reading are therefore important engineering skills. Photo: NFB

In the case of complex equipment, operation or maintenance may be carried out under the direction of an engineer. He will be responsible for seeing that proper operating conditions and performance are maintained, or arrange for regular maintenance, including a schedule of inspection, cleaning, parts replacement and overhaul.

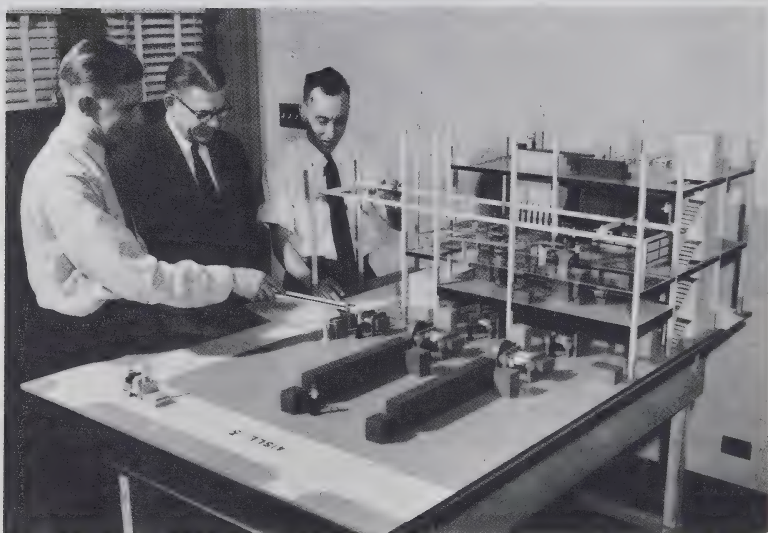
Construction, Installation, Erection

This function applies mainly to those engineers who are in charge of on-site construction work. They direct and oversee the workmanship and building material that go into the project, maintain the proper sequence of work and, in general, ensure that construction is carried out according to design and schedule.

Although installation of technical equipment is often carried out by technicians and tradesmen, it is necessary for engineers to supervise and direct installation of more complex equipment.

Field Exploration

Field exploration in Canada is chiefly identified with seeking out and proving mineral resources, but it also includes soil testing at the site where large structures are to be erected; hydrographic survey for water power, irrigation or flood control; investigation of perma-



It is quite apparent that scale models are an important stage in most engineering projects. The layout for this rubber mill can be studied, and changed if necessary, before construction or operation starts. Photo: Graetz Bros. Limited, Montreal

frost depths, and other exploration of engineering importance. This work usually involves travel, often in winter, to distant and unsettled regions, by whatever means of transportation available. Use of electromagnetic and seismic instruments, diamond drilling and examination of core samples is customary in this type of work.

* * *

The functions outlined above are the ones associated with the purely *technical* aspects of engineering. They are seldom neatly separated, as the above arrangement might suggest. There are also a number of other functions closely related to or dependent on a professional knowledge of engineering.

Consulting is not a function in the same sense as those outlined above or below; rather, it is a type of employment in which engineers, in business for themselves or in partnership with other engineers, render a variety of professional engineering services to clients on a fee basis. Consulting offers opportunities for engineers, so inclined, to work on their own account rather than as employees. It gives them a measure of independence not enjoyed by employees but demands high technical competence and exceptional personal qualities. Consulting offers a wider scope for technical practice and demand for such services appears to be growing.

Consulting engineers provide a variety of professional engineering services on a fee basis. Photo: NFB

Sales, Service, Marketing, Purchasing

There is a growing need for sales representatives with engineering knowledge to handle technical products. Such people must, of course, have good sales ability, and an engineering background enables them to discuss intelligently the engineering principles and elements of their firm's products with the prospective buyer's engineering staff.

Teaching, Instructing and Extension Work

One of the requisites of a profession is that its members concern themselves with the transmission of their knowledge to those willing and able to learn. A great deal of teaching is done by engineers, formally and informally, on the job, but in Canada, primary responsibility for teaching fundamental engineering rests with the universities.

The professor of engineering at a university has advantages besides the satisfaction of passing on knowledge of engineering to students; he may also find this the best way to acquire time and facilities for research. Engineers are also well qualified to teach in institutes of technology, where technicians who assist engineers are trained. With teacher-training, engineers may teach the subjects that form the basis of their profession—mathematics, chemistry and physics—in secondary schools and colleges. (See CANADIAN OCCUPATIONS Monograph No. 44, *Teacher*.)

Administration (*Management and Executive Posts*)

Most of the routine, detailed, and physical labour in any engineering project is done by unskilled, skilled and semi-professional workers to whom the engineer must delegate authority and communicate instructions. Thus, almost every engineering position entails supervision of some staff.

As business and industry become more and more concerned with modern technology and scientific management, the technical background of the engineer is of increasing value in administrative and executive positions. Advancement to these positions usually leads to duties with less and less technical content as the administrative function becomes increasingly important (see Levels E and F, p. 44) and many qualified engineers performing this function undoubtedly consider themselves primarily executives, rather than engineers.

Distribution of Engineers by Work Function in Selected Specializations, 1962

Work Function	Specialization										
	Total	Aeronautical	Chemical	Civil	Electrical	Industrial	Engineering Physics	Mechanical	Metallurgical	Mining	Petroleum
	%	%	%	%	%	%	%	%	%	%	%
Research and development	7	22	16	2	7	4	26	5	25	6	4
Design	18	21	5	23	20	5	15	22	2	7	3
Production, operation, maintenance	15	9	25	6	13	10	12	18	25	23	47
Construction, installation, erection	11	3	2	25	6	4	1	7	2	6	4
Field exploration	2	—	—	1	—	1	2	—	1	8	3
Sales, service, marketing, purchasing	10	4	13	4	12	27	11	15	10	8	6
Teaching, instructing, extension work	3	4	4	3	4	4	7	3	1	2	1
Administration	26	26	24	29	28	34	17	24	19	30	20
Other	8	11	11	7	10	11	9	6	15	10	12
Total	100	100	100	100	100	100	100	100	100	100	100

SOURCE: Economics and Research Branch, Department of Labour, Ottawa. The data relate to a total of 10,399 engineers surveyed by the Department in 1962.

PERSONAL QUALITIES NEEDED FOR SUCCESS

A prospective engineer should combine much curiosity regarding the how and why of Nature's laws and phenomena, with incentive to learn the answers. This will be demonstrated in practice in a strong interest and ability in secondary school physical sciences: mathematics, chemistry and physics.

In contrast to the scientist, who is concerned with knowledge for its own sake, the engineer as an *applied* scientist usually deals with practical problems. At the same time, the prospective engineer must be imaginative, because he will need to explore the universe of possibilities, and visualize what he seeks to create in terms of size, form, and function. He must be a "practical dreamer"—inquisitive, analytical, creative—yet always guided by cost. The engineer must produce things that are practicable as engineered creations, but they must also be economically feasible. Hence prospective engineers must not be averse to long and careful pondering of the inevitable financial aspects in every engineering project.

An engineer needs the faculty for working with other people, as his plans are often carried out through and by others. He needs qualities of leadership to convince and persuade, and to assume the role of responsibility that is customarily the engineer's. If a student does not want to be involved or bothered by supervisory duties or teamwork, perhaps one of the physical science fields would be a better choice.

The engineer must communicate with his assistants, employers, and colleagues, and produce plans, specifications and reports, using the written and spoken word. To some extent command of words is a natural talent, but clear, effective speaking and writing can be cultivated.

Like all pure and applied sciences, engineering at school and engineering on the job have this in common: much study, analysis, and thought is necessary. Not only must the working engineer exercise his mental capacity to meet new situations, he must also keep abreast of developments in engineering and the natural sciences. Engineering is extremely dynamic in that it is constantly improving its methods and knowledge in order to produce the innovations in goods and services which are characteristic of our economy.

Women in Engineering

It should be evident to anyone reading this monograph that there is no reason why a woman might not be a successful engineer. Nevertheless, although women may be found in every major field of engineering in Canada, the total number of women in the profession is extremely small.

On the whole, women tend to perform a narrower range of engineering duties than men; their more usual functions are research, testing, inspection, laboratory services, teaching, and certain production work. In other words, women are unlikely to be employed where a high degree of mechanical or manual activity is required.

No legal restrictions prevent women from entering the profession. However, certain aspects of engineering work tend to be regarded as less suitable for them than for men. Then, too, employers may hesitate to send women to remote locations or to put them into hazardous situations such as engineers sometimes meet.

Although engineering is traditionally a man's job, many engineering functions can be performed by women. This young lady, who made headlines by being the first female engineering graduate from McGill University in ten years, thinks there is no reason why more women shouldn't enter the field if they have the same interest and aptitude. Photo: Montreal Gazette

It is apparent, therefore, that the woman engineer is likely to have difficult hurdles to take, but if she has the appropriate aptitudes and interests and is willing to persevere in the face of obstacles, she may be assured of a satisfying career.

PREPARATION AND TRAINING

Secondary School

High school is the place to begin preparing for an engineering career. The engineering curriculum is one of the heaviest, fullest schedules of lectures and assignments at university and calls for the best efforts even of good students. It is in high school that prospective engineering students should form efficient study habits that will help carry them through the university course.

High school provides the groundwork of a good *general* education that includes English (or French), another modern language, and history, as well as mathematics and science.

Success in engineering will depend in great measure on a thorough training in the fundamental sciences: physics and chemistry, and a facility with the language of all science, mathematics. This is emphasized by the requirements for admission to the courses in engineering at Canadian universities. All stipulate a minimum standing of 60 per cent in final-year high school papers in algebra, geometry, trigonometry, physics and chemistry. Some require an average of 66 per cent.

University

Four years of study at a university faculty of engineering, following senior matriculation, is the customary education for engineers in Canada. The first year or two consists of general engineering principles; specialization as to field (e.g., civil, mechanical, electrical), is not covered until the third and fourth years. Some colleges that do not grant degrees in engineering offer a preparatory one or two-year general course, following which the student transfers to a degree-granting institution for the final years of specialization. A representative curriculum of subjects (the same for all engineering

fields) for the first and second year after senior matriculation would include the following:

Mathematics: algebra, geometry (analytical and descriptive), trigonometry, calculus, statistics

Natural Sciences: chemistry (organic and inorganic), physics (electricity, magnetism, heat, sound, light), geology

Introductory Engineering: mechanics, materials and their strength, engineering drawing, surveying (field work), mapping, engineering problems

Language: English composition (French in French-language institutions)

Social Sciences: modern world history, history of engineering, history of science, engineering law.

Most of these subjects will have been taken by the engineering student by the end of the second year at university. Third and fourth years, while continuing at a higher level some of the courses in the basic mathematics and sciences and general engineering of first and second years, are composed largely of courses pertaining to the subject matter of the particular field selected by the student as a specialty. The student also has some flexibility in these

Surveying is a basic skill learned by all engineering students.
Photo: NFB

last two years to prepare for certain specialties within the individual field, in being allowed to choose those he prefers among the optional courses offered. University calendars outline in detail the courses and options which are available for each field of specialization.

It is helpful for engineers in Canada to be bilingual. In French-language institutions, English-language text books are used for most of the courses in applied engineering and even several of the theoretical courses, along with texts printed in France, though all lectures are given in French. This is done to acquaint students with North American engineering methods which they will be in the main expected to practise (rather than French or European) and prepare them to co-operate and work with English-speaking engineers. Engineers whose mother tongue is English find a knowledge of French useful since many of the people with whom they work, especially in Quebec, may be French-speaking.

The trend in engineering education is toward broadening the courses by including more of the humanities and social sciences, even to the extent at some universities of arranging for the Bachelor of Arts degree to be earned in an additional year after the four years for the Bachelor of Engineering. Study of such subjects as language, economics, modern world history, political science, philosophy of science occupies approximately six per cent of the total time of the four undergraduate years at Canadian universities.

First engineering degrees are called either Bachelor of Engineering or Bachelor of Applied Science, depending on the university usage. A notation is made on the diploma as to the field and optional specialties taken. Undergraduate engineering courses taught at Canadian universities are listed on p. 50.

Fees and Living Expenses

The approximate range of fees, per year, for tuition is $300 to $700, depending on the educational institution. Living expenses must also be considered, especially if the student lives away from home. Living accommodation, including room, board, and laundry, may cost from $350 to $850 per annual session, and does not include such items as transportation, text-books and supplies, clothes, entertainment, and other personal expenditures. University calendars usually give information on fees, type of accommodation available and approximate cost.

Part of the expense of taking a university course can be met by earnings during summer vacations. There is also a steady increase in financial assistance for deserving students. Assistance is in the form of scholarships, bursaries, loan funds, etc., details of which may be obtained from your school principal, vocational guidance counsellor, or from university calendars.

Post-Graduate Study

Surveys made by the Economics and Research Branch of the Department of Labour indicate that while over 85 per cent of engineers surveyed have a bachelor degree in engineering less than ten per cent hold a master's degree, and not more than one per cent, doctorates. A master's degree may be earned in one year after a bachelor degree; a doctorate in two years after a master's. Approximately four per cent of the engineers are not university graduates, but entries into the profession in the past ten years or more have nearly all been by university degree. The tendency is more and more not only to formal training in a higher educational institution as an absolute requirement, but there is also increasing demand for engineers with master's degrees or doctorates. Surveys by the National Research Council reveal that students enrolled in graduate engineering studies at Canadian universities have risen to 1,098 for 1962-63 from 225 for 1953-54—an increase of nearly five times in the last nine years!

Vacation and Part-time Employment

It is a generally accepted practice that, before the engineering degree is granted, a candidate is required to satisfy the college or faculty of engineering that he has completed a suitable amount of practical work related to engineering. Requirements range from laboratory or field work at the university to summer vacation employment.

Training in Industry

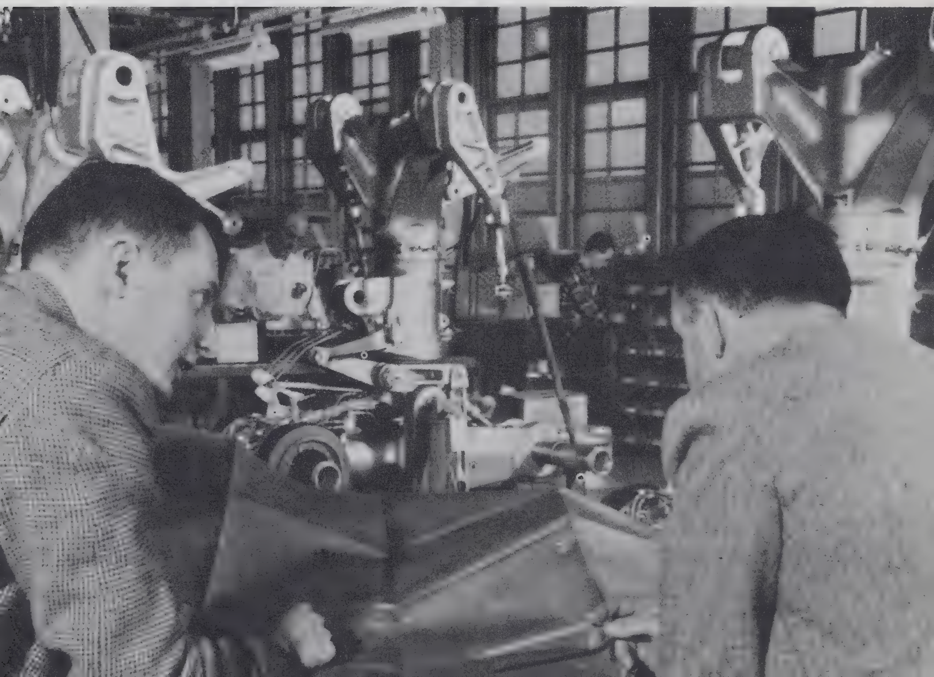
Nearly all employers give newly graduated engineers a variety of assignments to help them get acquainted with the firm's operations. Most of the larger employers have long-term plans for future growth and encourage men with ambition by sponsoring company training courses, on salary, either on their premises or at nearby educational institutions. Trips to technical meetings are sponsored

and committee and seminar activity is fostered, so that young engineers can learn by contact with experts in their field. Many firms have excellent libraries and laboratories and make time available for research.

Qualifying by Private Study

It is possible for persons not holding an engineering degree to study privately, pass examinations set by the provincial associations of professional engineers and in that way qualify as professional engineers (P. Eng.). This takes many years to do by home study, with little recognition along the way, and only a small number have been successful. For further information, prospective candidates should consult the Registrar of the association in their province (see below for list of associations and addresses).

After graduation the young engineer still has a great deal to learn. Practical experience, often in conjunction with company training, adds to his competence as a professional engineer. Photo: NFB



ENTRY INTO THE PROFESSION

The prime requisite for entry into the engineering profession is technical competence gained through adequate training and practical experience. Those wishing to use the title "Professional Engineer" (P. Eng.), and legally practise the engineering profession must be registered with their provincial association of professional engineers.

Registration as a professional engineer requires, as a minimum qualification, a bachelor degree in engineering or applied science from a recognized university or college and two years of practical engineering experience. The equivalent of a degree is the passing of examinations set or approved by the provincial associations. An engineering graduate who is in the process of attaining the required experience may use the title "Engineer-in-Training" or, in Quebec, "Junior Professional Engineer". Undergraduates in university, or persons planning to write the examinations set by an association, may be registered with the association as students. Details of individual requirements for each province may be obtained from the following:

The Canadian Council of Professional Engineers,
116 Albert Street,
Ottawa, Ontario.

Association of Professional Engineers of the Province
of British Columbia,
2210 West 12th Avenue,
Vancouver 9, B.C.

Association of Professional Engineers of Alberta,
123 Commercial Building,
10120 Jasper Avenue,
Edmonton, Alberta.

Association of Professional Engineers of Saskatchewan,
404 MacCallum Hill Building,
Regina, Sask.

Association of Professional Engineers of the Province of Manitoba,
Room 418, 265 Portage Ave.,
Winnipeg 2, Manitoba.

Association of Professional Engineers of the Province of Ontario,
236 Avenue Road,
Toronto, Ontario.

Corporation of Professional Engineers of Quebec,
1600 Pine Avenue West,
Montreal 25, P.Q.

Association of Professional Engineers of the Province of
New Brunswick,
Room 134, Union Station,
Saint John, N.B.

Association of Professional Engineers of the Province of
Nova Scotia,
P.O. Box 731,
Halifax, N.S.

Association of Professional Engineers of the Province of
Prince Edward Island,
242 North River Road,
Charlottetown, P.E.I.

Association of Professional Engineers of the Province of
Newfoundland,
P.O. Box 31,
St. John's, Newfoundland.

Association of Professional Engineers of the Yukon Territory,
P.O. Box 812,
Whitehorse, Y.T.

Placement Assistance

The great majority of engineers work as salaried employees, according to the 1961 Census of Canada. In order to become established in the profession, prospective engineers must therefore locate an employer and satisfy him as to their personal qualifications and technical competence. Several sources of assistance are available to engineers and engineering students seeking employment.

Information about job opportunities can be secured from the Executive and Professional Division of the National Employment Service, which works in co-operation with placement officers in universities.

Recruiting campaigns at the universities were started by private industry and business during the recent engineer shortage, graduates often having a choice of two or three different jobs. This was an unusual condition not likely to last after the engineering supply and demand had become stabilized, but it is quite possible that employers will continue to seek out good engineering graduates at the universities.

Professional and technical associations also provide services

designed to bring together prospective employers and engineers seeking employment. These include employment registers, published lists of vacancies, and employment desks at association meetings.

Daily and weekly newspapers, technical journals, and company brochures often list engineering opportunities.[1] Many students make contacts through summer employment which provide them with permanent positions upon graduation.

Governments at all levels—municipal, provincial and federal—are extensive employers of engineering services. Canada-wide competititions for engineering positions with the federal government are posted in public buildings such as post offices, local offices of the National Employment Service and the Civil Service Commission, and notices are carried in the daily newspapers.

Engineers Trained Outside of Canada

Engineers who have received their training in another country and wish to practise in Canada as professional engineers must meet the legal requirements of the province where they intend to practise. These requirements vary somewhat from province to province, and exact information may be obtained from the Canadian Council of Professional Engineers or the Registrar of the appropriate provincial association. The provincial associations recognize a substantial number of engineering degrees from universities in all parts of the world. Individuals who do not hold such a degree are required to pass written examinations.

It is pointed out that in Canada, qualification for the engineering profession is not at all the same as certification for marine and stationary engineers.

WORKING CONDITIONS

Professional engineers work under widely varying conditions, depending on their function at a particular time and the field in which they specialize. They may be called from the relative quiet of the research laboratory and drafting room to the heat or noise of the factory shop; they may leave the comfort of the engineering office and travel perhaps hundreds of miles to take care of an

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[1]See also *Engineering Careers in Canada*, published annually by the Engineering Institute of Canada.

emergency at a distant engineering project. Engineers are employed throughout Canada; the majority live and work in Ontario and Quebec, being concentrated in large urban centres. Many Canadian engineers are working on projects in foreign countries.

As leader of the engineering team, the engineer must take the responsibility for decisions involving the expenditure of large sums of money and affecting the lives and safety of workmen. Failure of a project during construction, or after its completion, may have costly and disastrous results.

Engineers' working hours usually conform to plant or office hours where they are employed, but periods of emergency, difficult technical problems, or production deadlines to be met may involve long hours, sometimes under trying conditions. Engineers also have a professional responsibility to keep abreast of technical developments in their field by reading, conferring with engineering colleagues, or attending seminars.

EARNINGS AND ADVANCEMENT

The salaries and promotions of professional engineers reflect the individual's responsibilities, performance, and qualifications generally. Some companies place as much importance on seniority as on merit, but high technical achievement is usually well rewarded.

The most remunerative positions within engineering are in the consulting field, administration, and contracting. High salaries are paid for service in remote areas, probably a form of compensation for working and living conditions and travel away from home.

The careers of professional engineers follow such a wide variety of patterns, depending on individual abilities and circumstances, that no single pattern could be considered representative. A solution to the problem is found in the report of a survey[1] which relates level of responsibility with salary and in so doing, provides some indication of the possible progress of an engineer's career. The following outline is abstracted from the report; a bachelor degree in engineering or applied science, or its equivalent, is prerequisite for each level.

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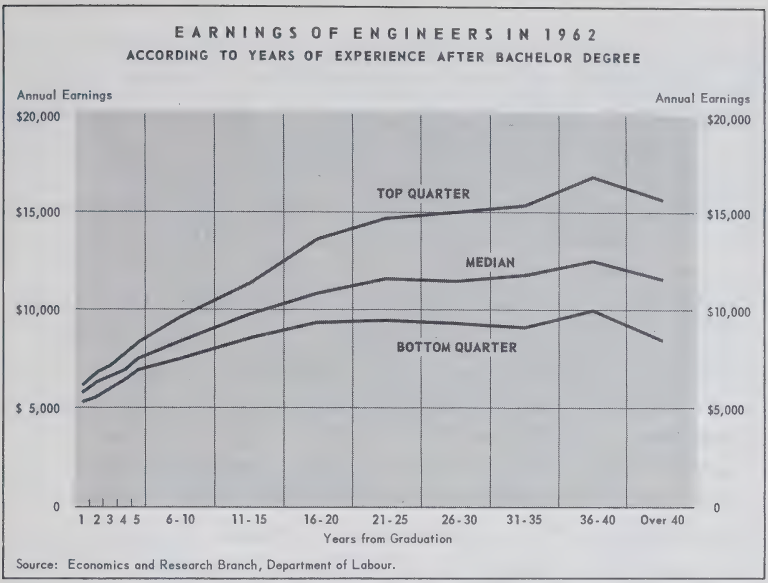
[1]Canadian Council of Professional Engineers, *Report on Salaries of Professional Engineers by Levels of Responsibility as of July 1, 1963*, available on request from the Council. (Salaries as reported for Ontario, Quebec, Alberta and British Columbia).



Level A: The beginner, with little or no practical experience, is usually given duties of a routine nature in office, plant, field or laboratory, under close supervision. Median annual salary: $5,570.

Level B: Receives assignments of limited scope and complexity; assists more senior engineers in carrying out technical tasks requiring accuracy in calculation, completeness of data, and adherence to prescribed testing, analysis, design or computation methods. May give technical guidance to one or two junior engineers or technicians; must have at least two or three years engineering experience. Median annual salary: $6,720.

Level C: Carries out responsible and varied engineering assignments, requiring general familiarity with a broad field of engineering. Problems usually solved by use of combinations or modifications of standard procedures, or methods developed in previous assignments. Participates in planning to achieve prescribed objectives. Work is not generally supervised in detail, but receives guidance on more difficult features of the assignment. A minimum of three to five years of related experience is required. Median annual salary: $8,180.

Level D: This is the first level of true professional supervision, *or* full specialization, and requires the application of mature engineering knowledge in planning and conducting projects. Assignments are received in terms of objectives, relative priorities and critical areas. Work is carried out within broad guide lines, but informed guidance is available. The engineer assigns and outlines work, advises on technical problems, makes recommendations concerning selection, training, rating and discipline of staff. It usually takes 5 to 8 years to be promoted to this level. Median annual salary: $9,600.

Level E: Usually requires knowledge of more than one field of engineering, *or* performance by an engineering specialist in a particular field. Participates in short and long-range planning and makes independent decisions on work methods and procedures. May supervise large groups containing both professional and non-professional staff or may exercise authority over a small group of highly qualified professional personnel engaged in complex technical applications. Outlines more difficult problems and methods of approach. Co-ordinates work programs and directs use of equipment and material, and makes recommendations regarding personnel. It usually takes nine to twelve years of engineering and/or administrative experience to reach this level. Median annual salary: $11,280.

Level F: Usually responsible for an engineering administrative function, directing several professional and other groups engaged in interrelated engineering responsibilities, *or* as an engineering consultant recognized as an authority in an engineering field of major importance to the organization. Independently conceives programs and problems to be investigated, and participates in discussions determining basic operating policies. Reviews and evaluates technical work; selects, schedules, and co-ordinates to attain objectives; as administrator, makes decisions concerning staff. Usually thirteen years or more of engineering experience, including responsible administrative duties, is required to reach this level. Median annual salary: $13,500.

Having advanced beyond this level, the engineer operates with broad management authority, receiving virtually no technical guidance and control, limited only by general objectives and policies of the organization. He plans or approves projects requiring the expenditure of a considerable amount of money and man-power. He is responsible for long-range planning, co-ordination, and making

specific and far-reaching management decisions. He is expected to possess a high degree of originality, skill and proficiency in the various broad phases of engineering application. This level is reached only after many years of authoritative engineering and administrative experience. Remuneration is usually commensurate with level of responsibility, ranging far beyond the salary reported for the previous level.

A word of caution is in order. An attractive salary is not the only consideration when seeking job satisfaction. The interest, challenge, or opportunities for professional development, offered by various types of employment, should be carefully investigated in terms of one's own personal aspirations and set of values.

OUTLOOK FOR ENGINEERS

Engineering activity varies from year to year, depending on economic conditions, causing short-term fluctuations in the demand for engineers. Vocational guidance counsellors and high school students are cautioned against basing long-range career decisions on short-term and often transitory employment conditions. There is a notable coincidence, for example, in the slackening demand for engineers in 1958 and 1959 and a corresponding decrease in engineering enrolments for these two years. The decision by a student in the final year of high school to become an engineer will not bear fruit for nearly five years, and this will mark but the beginning of a productive life that can be expected to last 40 to 50 years. To base such a decision on anything but a long-term outlook would hardly seem valid. There are serious limitations to our ability to predict the distant future with accuracy, but broad generalizations can be made.

> *Basically, the engineering employment outlook depends on the growth potentiality of those industries which employ engineers in the largest numbers, and upon any trends in these industries which would make the functions performed by engineers more or less important.*

It is very significant that the recent and most exhaustive survey of Canada's economic future, carried out by the Royal Commission on Canada's Economic Prospects, found that most of the major employers of engineers (mining companies, manufacturing firms, construction contractors, and public utilities, including transporta-

tion and communication companies) are among those expected to be the fastest growing ones over the next two decades. In no case is their growth expected to be less than average. It can be concluded, therefore, that the industries which employ engineers in greatest numbers are also, by and large, those with the best future growth possibilities.

Apart from the growth of industries mentioned above, there is reason to believe that the demand for the services which engineers perform will increase even more rapidly. In today's world, economic growth is becoming more and more dependent on the practical use in the factory and in business, of as many as possible of the latest scientific discoveries. *This is exactly the task of the engineer and the technician.*

The wide range of functions performed by engineers has already been outlined, and it should be re-emphasized that employers do not hire engineers only for complex technical jobs. Many people with an engineering education find their way very quickly into jobs which, at least on the surface, do not seem to require much technical knowledge. Thus engineers are found in sales jobs, in market analysis work, and in a great variety of administrative and executive positions. What is known about the kinds of careers followed by engineers makes it very clear that management has found it can utilize them efficiently in a wide range of jobs, many of which have little technical content.

It is because of this that many firms hire engineers, usually new graduates, not primarily because of their suitability for a specific technical job, but rather because of their *potential qualities* which, through training and experience with the firm, will enable them to make an important contribution in a variety of positions, including, in due course, management itself.

To summarize, future employment prospects for engineers in Canada are very good. Not only are the industries which employ most of them expected to be, by and large, fast-growing ones in the future, but also the needs of these industries for people with engineering education will increase more rapidly.

SOURCES OF ADDITIONAL INFORMATION AND GUIDANCE

The organizations of professional engineers welcome inquiries from students and persons with questions regarding the engineering

profession. The office of the National Employment Service in your area can provide local information. University calendars, which may be obtained on request, outline academic requirements, detailed course content, financial aid, and tuition and living costs. Specific questions may be directed to the appropriate staff members.

Practising engineers possess a wealth of first-hand experience which they are usually willing to share with the interested student. Since this source provides a very individual point of view the student should, if at all possible, interview several engineers.

Almost any issue of the daily newspapers and financial publications contain some reference to engineering. Technical journals and books on engineering are available in public libraries. The student who is alert to information regarding engineering will notice the abundance of such items. In this way may be accumulated a knowledge of engineering in Canada and the world, which is available from no other source. Biographies of successful professional engineers often yield a personal insight of qualities that make a good engineer and the challenges and rewards that engineering has to offer.

Professional engineering associations help career-conscious students to get a glimpse of what engineering is like. Photo: Victor Aziz—London

Further Reading

Books

Beckhard, Arthur J. *Electrical Genius, Nikola Tesla.* New York; Messner, 1959.

Beatty, Charles. *Ferdinand de Lesseps.* London; Eyre and Spottiswood, 1956.

Forbes, R. J. *Man the Maker.* London and New York; Abelard-Schuman, 1958.

Hill, T. L. *The St. Lawrence Seaway.* London; Methuen & Co., 1959.

Norway, Neville Shute. *Slide Rule.* New York; Morrow, 1954.

Parr, J. G. *Man, Metals and Modern Magic.* Cleveland; American Society for Metals, 1958.

Rowland, John, *Epics of Invention.* London; Werner Lurie, 1957.

Bulletins and Pamphlets:

The Canadian Forester in His Job. Canadian Institute of Forestry, 1958.

The Profession of Chemical Engineering in Canada. A Vocational Guidance Booklet for High School Students, The Chemical Institute of Canada, Ottawa: 1959.

Engineering—A Creative Profession. Engineer's Council for Professional Development, New York; 1956.

Opportunities for Graduates in Engineering and Physical Sciences. Civil Service Commission of Canada, Ottawa.

Engineering Careers in Canada. The Engineering Institute of Canada, Montreal.

A Professional Guide for Junior Engineers, 1949. The Engineering Institute of Canada, Montreal: 1949.

The Guidance Centre, Ontario College of Education, University of Toronto. Monographs, *Engineer—Professional*, 1963, *Chemical Engineer*, 1963, *Metallurgist—Metallurgical Engineer*, 1963.

The Engineering Profession, Association of Professional Engineers of the Province of Manitoba, Winnipeg, 1959.

APPENDIX

Other organizations with engineering membership:

The Engineering Institute of Canada,
2050 Mansfield Street,
Montreal, P.Q.

The Chemical Institute of Canada,
48 Rideau Street,
Ottawa, Ontario.

The Canadian Institute of Mining and Metallurgy,
906 Drummond Building,
Montreal 2, P.Q.

The Canadian Institute of Forestry,
10 Manor Road West,
Toronto 7, Ontario.

The Canadian Forestry Association,
4795 St. Catherine Street West,
Montreal, P.Q.

The Canadian Aeronautics and Space Institute,
77 Metcalfe Street,
Ottawa, Ontario.

Association of Consulting Engineers of Canada,
Room 604,
620 Cathcart Street,
Montreal, P.Q.

Canadian Agricultural Engineering Society,
c/o Ontario Agricultural College,
Guelph, Ontario.

First Degree Engineering Courses, 1963-64

Name of Institution	Ag., Ag. Enging.	Chemical	Civil	Electric l	Geological	Mechanical	Metallurgical	Mining	Eng. Physics	Forestry, For. Eng.	Other Fields
University of Alberta, Edmonton	x	x	x	x		x	x	x	x		Appl. Math. (Hon.)
University of British Columbia, Van.	x	x	x	x	x	x	x	x	x	x	
Carleton University, Ottawa			x	x		x			x		Appl. Phys. (Hon.)
Dalhousie University, Halifax									x		
Université Laval (F), Québec	x	x	x	x	x	x	x	x	x	x	Surveying, Fisheries.
University of Manitoba, Winnipeg	x		x	x	x	x			x		
McGill University, Montreal	x	x	x	x		x	x	x	x		Appl. Math. (Hon.)
McMaster University, Hamilton		x	x	x		x	x		x		Appl. Math. (Hon.)
Université de Montréal (F), Montréal		x	x	x	x	x	x	x	x		
University of New Brunswick, Fredericton		x	x	x		x				x	Surveying
Université d'Ottawa (F & E), Ottawa		x		x							
Queen's University, Kingston		x	x	x	x	x	x	x	x		
Royal Military College of Canada, Kingston		x	x	x		x			x		
University of Saskatchewan	x	x	x	x	x	x		x	x		Petroleum
Université de Sherbrooke (F), Sherbrooke			x	x		x					
Sir George Williams University, Montreal			x	x		x					
University of Toronto, Toronto	x	x	x	x	x	x	x	x	x	x	Aeronautical/Astro. Industrial Eng. Science.
Federated Colleges, Guelph	x										First four years of five years program in Civil & Mech.
University of Waterloo, Waterloo		x	x	x		x					
University of Western Ontario, London		x	x	x		x					
University of Windsor, Windsor		x	x	x		x			x		

Note: F—French only. F & E—French and English.

In addition to the above institutions which grant first degrees in the engineering fields indicated, the following institutions offer the first three years of a five-year engineering course: Acadia University, Wolfville; Dalhousie University, Halifax; Memorial University of Newfoundland, St. John's; Loyola College, Montreal; Mount Allison University, Sackville, N.S.; St. Dunstan's University, Charlottetown, P.E.I.; St. Francis Xavier University, Antigonish, N.S.; Université St. Joseph (F. & E.), St. Joseph, N.B.; St. Mary's University, Halifax; Sir George Williams University, Montreal; Lakehead College of Arts, Science and Technology, Port Arthur, Ont. Completion of the junior course then requires an additional two years at a degree-granting institution.

SOURCE: Canadian Universities Foundation.

Cours de génie, premier grade, 1963-1964

Institution	Agronomie, génie agricole	G. chimique	G. civil	G. électrique	G. géologique	G. mécanique	G. métallurgique	G. minier	G. physique	Sylviculture G. forestier	Autres domaines
Université d'Alberta, Edmonton	x	x	x	x		x	x	x	x		Math. appl. (Sp.)
Université de Colombie-Britannique, Vancouver	x	x	x	x	x	x	x	x	x	x	
Université Carleton, Ottawa			x	x		x			x		Phys. appl. (Sp.)
Université Dalhousie, Halifax									x		
Université Laval (F), Québec	x	x	x	x	x	x	x	x	x	x	Arpentage, Pêcheries
Université du Manitoba, Winnipeg	x		x	x	x	x			x		
Université McGill, Montréal	x	x	x	x		x	x	x	x		Math. appl. (Sp.)
Université McMaster, Hamilton		x	x	x		x	x		x		Math. appl. (Sp.)
Université de Montréal (F), Montréal		x	x	x	x	x	x	x	x		
Université du N.-Brunswick, Fredericton		x	x	x		x				x	Arpentage
Université d'Ottawa (F, A), Ottawa		x		x							
Université Queen's, Kingston		x	x	x	x	x	x	x	x		
Collège militaire royal du Canada, Kingston		x	x	x		x			x		
Université de Saskatchewan	x	x	x	x	x	x		x	x		Pétrole
Université de Sherbrooke (F), Sherbrooke			x	x		x					
Université Sir George Williams, Montréal			x	x		x					
Université de Toronto, Toronto	x	x	x	x	x	x	x	x	x	x	Aéronautique Astron. Organisation industrielle
Collèges fédérés, Guelph	x										4 premières années du cours de 5 ans en génie civil et mécanique.
Université de Waterloo, Waterloo		x	x	x		x					
Université de l'Ouest de l'Ontario, London		x	x	x		x					
Université de Windsor, Windsor		x	x	x		x			x		

N.B. (F) : français seulement (F, A) : français et anglais

En plus des institutions ci-dessus qui accordent le premier grade dans les branches de génie indiquées, les institutions ci-après offrent les trois premières années du cours de cinq ans en génie: Université Acadia, Wolfville; Université Dalhousie, Halifax; Université Memorial de Terre-Neuve, Saint-Jean; Collège Loyola, Montréal; Université Mount Allison, Sackville (N.-É.); Université St-Dunstan, Charlottetown (I. P.-É.); Université St-François-Xavier, Antigonish (N.-É.); Université St-Joseph, (F, A), St-Joseph (N.-B.); Université St-Mary, Halifax; Université Sir George Williams, Montréal; Lakehead College of Arts, Science and Technology, Port-Arthur (Ont.). Il faut ensuite terminer le cours par deux années d'études dans une université qui décerne le grade.

SOURCE: Fondation canadienne des universités.

APPENDICE

Autres associations d'ingénieurs

L'Institut des ingénieurs professionnels du Canada,
2050, rue Mansfield,
Montréal 2 (Québec).

L'Institut de Chimie du Canada
48, rue Rideau,
Ottawa (Ont.).

L'Institut canadien d'exploitation minière et de métallurgie,
906, Immeuble Drummond,
Montréal 2 (Québec).

L'Institut forestier du Canada,
10, Chemin Manor ouest,
Toronto 7 (Ont.).

L'Association forestière du Canada,
4795, rue Sainte-Catherine ouest,
Montréal (Québec).

L'Institut Aéronautique et Spatial du Canada,
77, rue Metcalfe,
Ottawa (Ont.)

L'Association des ingénieurs-conseils du Canada,
Pièce 604,
620, rue Cathcart,
Montréal (Québec).

Société canadienne du génie agricole,
a/s Collège d'agriculture de Guelph,
Guelph (Ont.).

Autres ouvrages à consulter

Le Comité canadien d'orientation en génie et en sciences. *Science, Génie.* Ottawa.

La Commission du service civil du Canada, Ottawa:
Carrières de l'État pour les diplômés universitaires (1953).
Emplois disponibles pour les diplômés en génie et en physique.

Conseil de recherches pour la défense. *Possibilités d'emploi au Conseil de recherches pour la défense.* Ottawa. L'Imprimeur de la Reine, 1959.

L'École de pédagogie et d'orientation de l'Université Laval. *L'enseignement des sciences au Canada francais.* Québec, 1948.

The Engineering Institute of Canada. *La profession d'ingénieur au Canada.* Montréal (Brochure publiée chaque année.)

L'Institut de chimie du Canada. *La carrière d'ingénieur chimiste.* Ottawa, 1958.

Ministère des Mines et des Relevés techniques. *Votre carrière au ministère des Mines et des Relevés techniques.* Ottawa, l'Imprimeur de la Reine, 1959.

Le Secrétariat de la province de Québec. *Pour l'avenir de nos jeunes.* Montréal, 1945.

emplois qui, dans bien des cas, sont étrangers au domaine technique.

Voilà pourquoi beaucoup d'entreprises emploient des ingénieurs, d'ordinaire de nouveaux diplômés, non pas tant à cause de leur compétence pour accomplir un travail technique particulier, mais plutôt à cause de *qualités latentes* qui, grâce à la formation et à l'expérience reçues dans la société, permettront à ces jeunes de rendre de grands services dans divers postes, y compris, en temps utile, la direction.

Bref, les perspectives d'emploi pour les ingénieurs sont très bonnes au Canada. On s'attend non seulement que les industries qui emploient le plus grand nombre d'entre eux prendront, dans l'ensemble, un essor rapide, mais aussi que ces industries auront de plus en plus rapidement besoin d'employés ayant une formation technique.

AUTRES SOURCES DE RENSEIGNEMENTS ET D'ORIENTATION

Les organismes d'ingénieurs professionnels accueillent volontiers les questions que posent les étudiants ou autres personnes au sujet de la profession d'ingénieur. Les bureaux régionaux du Service national de placement fournissent des renseignements d'intérêt local. L'annuaire des universités, que l'on peut obtenir sur demande, renseigne sur les exigences universitaires, sur les matières du cours, sur l'aide financière, sur les droits d'inscription et sur les frais de subsistance. On peut adresser les questions particulières aux membres du personnel en cause.

Les ingénieurs de métier ont une expérience de première main dont ils consentent d'ordinaire à faire part à l'étudiant intéressé. Comme il s'agit d'un point de vue tout à fait personnel, l'étudiant devrait, si possible, se renseigner auprès d'autres ingénieurs.

Dans presque tous les numéros des quotidiens et des publications financières il est question du génie. On trouve dans les bibliothèques publiques une foule de revues et de livres qui traitent du génie. L'étudiant qui cherche des renseignements sur le génie constatera qu'il y a abondance de ces publications. On peut de la sorte accumuler, sur le génie professionnel au Canada et dans le monde, des connaissances qu'on ne saurait trouver ailleurs. La biographie d'ingénieurs qui ont réussi dans la profession indiquera souvent à l'étudiant les qualités personnelles qui font un bon ingénieur, et les défis et récompenses qu'offre le domaine du génie.

bout d'environ cinq ans, alors que commencera une vie productive qui peut durer de 40 à 50 ans. On n'aurait guère raison de fonder une telle décision sur autre chose que des prévisions à long terme. Il est très difficile de prévoir exactement ce que sera l'avenir, mais on peut généraliser.

> *En somme, les perspectives d'emplois pour les ingénieurs dépendent de la mesure où grandiront les industries qui emploient beaucoup d'ingénieurs et de ce que, dans ces industries, on tendra à donner une plus ou moins grande importance aux fonctions des ingénieurs.*

Fait très significatif, l'étude la plus récente et la plus complète effectuée au sujet de l'avenir économique du Canada, l'étude qu'a faite la Commission royale d'enquête sur les perspectives économiques du Canada, révèle que la plupart des grandes entreprises qui emploient des ingénieurs (sociétés minières, entreprises de fabrication ou de construction, services publics, en particulier les sociétés de transport et de communications) sont parmi celles qui, s'attend-on, grandiront le plus rapidement durant les deux prochaines décennies. Dans aucun cas on ne s'attend que leur croissance soit inférieure à la moyenne. Il s'ensuit donc que les industries qui emploient le plus d'ingénieurs sont aussi, dans l'ensemble, celles dont l'accroissement futur est le plus probable.

En plus de l'expansion des industries ci-dessus mentionnées, il y a raison de croire que la demande d'ingénieurs s'accroîtra encore plus rapidement. Dans le monde actuel, l'essor économique dépend de plus en plus de ce qu'on utilise le plus possible, à la fabrique et dans le commerce, les dernières découvertes scientifiques. *Voilà exactement la tâche de l'ingénieur et du technicien.*

On a déjà parlé de la grande diversité des fonctions que remplissent les ingénieurs et il faut redire que les employeurs n'engagent pas des ingénieurs uniquement pour des travaux techniques complexes. Beaucoup de personnes ayant une formation d'ingénieurs en viennent rapidement à occuper des emplois qui, apparemment du moins, ne semblent demander guère de connaissances techniques. Voilà pourquoi on trouve des ingénieurs dans les services des ventes, dans les travaux d'analyse des marchés et à divers postes d'administrateurs et de directeurs. Les données que nous avons sur les diverses carrières remplies par les ingénieurs indiquent nettement que la direction des entreprises s'est rendu compte qu'elle peut avantageusement leur confier de nombreux

et questions à étudier et il participe aux discussions où s'établit la ligne de conduite fondamentale à suivre. Il revise et évalue le travail d'ordre technique; il procède à des choix, à l'établissement des programmes et à leur coordination pour atteindre les objectifs désignés; en tant qu'administrateur, il prend des décisions touchant le personnel. Il faut treize ans ou plus d'expérience dans le génie, y compris des fonctions administratives de confiance pour attteindre cet échelon. Le salaire annuel médian est de $13,500.

Au-delà de cet échelon, l'ingénieur possède une grande liberté administrative, n'étant de fait soumis à aucune orientation ou surveillance d'ordre technique, mais devant s'en tenir uniquement aux objectifs et programmes généraux de l'organisme pour lequel il travaille. Il prépare ou approuve des projets qui réclament beaucoup d'argent et de main-d'œuvre. Il lui incombe d'établir des programmes à long terme, de coordonner et prendre des décisions administratives précises et d'une grande portée. On s'attend qu'il possède à un haut degré l'esprit d'invention, du talent et de la compétence par rapport aux secteurs nombreux et vastes de l'application du génie. Cet échelon n'est atteint qu'après de nombreuses années d'expérience comme ingénieur compétent et comme administrateur. La rémunération est d'ordinaire en proportion du degré des responsabilités, dépassant de beaucoup les salaires mentionnés aux échelons précédents.

Un avertissement s'impose. Le salaire n'est pas tout ce qui rend un travail agréable. L'ingénieur doit étudier soigneusement, en fonction de ses aspirations personnelles et de sa conception des valeurs, l'intérêt, la stimulation ou les occasions de progresser que présentent divers types d'emploi.

PERSPECTIVES D'AVENIR POUR LES INGÉNIEURS

Selon les conditions économiques, l'activité dans le domaine du génie varie d'année en année, ce qui donne lieu à de brèves fluctuations dans la demande d'ingénieurs. On prévient les conseillers d'orientation professionnelle et les étudiants des écoles secondaires de ne pas décider d'une carrière à portée lointaine d'après des conditions d'emploi d'une brève portée, souvent transitoires. Ainsi, il y a une coïncidence notable entre la demande moindre d'ingénieurs, en 1958 et 1959, et une diminution correspondante de l'inscription aux cours de génie, ces deux années-là. La décision du finissant d'école secondaire qui opte pour le génie ne portera fruit qu'au

ou de méthodes mises au point au cours de travaux antérieurs. Il participe au travail de préparation en vue d'atteindre les objectifs fixés. Son travail ne fait généralement pas l'objet d'une surveillance minutieuse; mais l'ingénieur reçoit les conseils nécessaires lorsque sa tâche présente certaines difficultés. On exige un minimum de trois à cinq années d'expérience analogue. Le salaire annuel médian est de $8,180.

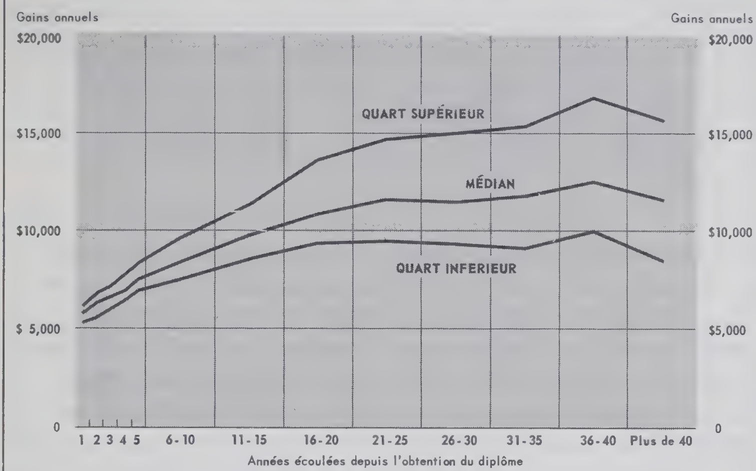
Échelon D: C'est le premier échelon de direction véritablement professionnelle ou de complète spécialisation; il exige une connaissance profonde du génie pour établir les projets et en assurer l'exécution. Les tâches sont assignées en fonction d'objectifs déterminés, de priorité relative et de secteurs vulnérables. Le travail est exécuté d'après des données générales, mais l'exécutant peut obtenir une orientation éclairée. L'ingénieur attribue les tâches dont il trace les grandes lignes, conseille au sujet des difficultés techniques et fait des recommandations relativement au choix, à la formation, au classement et à la discipline du personnel. Il faut ordinairement de cinq à huit ans pour atteindre cet échelon. Le salaire annuel médian est de $9,600.

Échelon E: Pour atteindre cet échelon, il faut connaître plus d'un domaine du génie ou pouvoir accomplir un travail de spécialiste dans un domaine particulier du génie. L'ingénieur participe à la préparation prochaine et lointaine des projets et décide par lui-même quant aux méthodes et aux procédés de travail. Il peut surveiller des groupes considérables formés de membres de la profession et d'autres, ou diriger un petit groupe de professionnels hautement spécialisés qui s'adonnent à des applications techniques complexes. Il indique dans les grandes lignes les problèmes difficiles et la façon de les régler. Il coordonne les programmes de travail, dirige l'emploi de l'outillage et du matériel et fait des recommandations au sujet du personnel. Il faut ordinairement une expérience de neuf à douze ans dans le génie ou dans l'administration pour atteindre cet échelon. Le salaire annuel médian est de $11,280.

Échelon F: A ce palier, l'ingénieur exerce généralement des fonctions administratives de nature technique, dirigeant plusieurs personnes de la profession ou d'autres affectées à des travaux techniques étroitement liés entre eux, OU il est employé à titre d'ingénieur conseil reconnu comme spécialiste dans un domaine technique très important pour l'entreprise en cause. Il conçoit seul les programmes

GAINS DES INGÉNIEURS EN 1962

SUIVANT LES ANNÉES D'EXPÉRIENCE APRÈS L'OBTENTION DU BACCALAURÉAT



Source: Direction de l'économique et des recherches, Ministère du Travail.

établit le rapport entre le degré de responsabilités et le salaire et, ce faisant, indique dans une certaine mesure les possibilités d'avancement qu'offre la carrière d'ingénieur. L'exposé qui suit a été tiré du rapport; le baccalauréat en génie ou ès sciences appliquées, ou l'équivalent, est une condition préalable à chaque échelon.

Échelon A: Le débutant, qui a peu d'expérience pratique ou n'en a pas du tout accomplit d'ordinaire, sous surveillance étroite, du travail au bureau, à l'usine, sur le terrain ou au laboratoire. Le salaire annuel médian est de $5,570.

Échelon B: On confie à cet ingénieur des tâches d'une certaine importance et complexité; il aide ses supérieurs à exécuter des travaux techniques qui comportent des calculs précis, l'exactitude des données et l'observance des méthodes prescrites d'expérimentation, d'analyse, de conception ou de calcul. Il peut donner les directives techniques à un ou deux ingénieurs ou techniciens moins anciens que lui; il doit avoir au moins deux ou trois années d'expérience dans le domaine du génie. Le salaire annuel médian est de $6,720.

Échelon C: A cet ingénieur, on confie l'exécution de tâches diverses et de confiance, qui exigent une connaissance générale d'un vaste domaine du génie. Il s'agit d'ordinaire de problèmes à résoudre par l'utilisation conjointe ou la modification des procédés ordinaires

passer du calme relatif du laboratoire ou de la salle de dessin à la chaleur ou au vacarme de l'usine; ils peuvent quitter le confort de leur bureau d'ingénieur et parcourir des centaines de milles peut-être pour répondre à un cas d'urgence dans une entreprise éloignée. On emploie des ingénieurs par tout le Canada. La majeure partie d'entre eux demeurent et travaillent en Ontario et dans le Québec, surtout dans les grands centres urbains. De nombreux ingénieurs canadiens travaillent à l'étranger.

En tant que chef d'une équipe technique, l'ingénieur doit prendre des décisions comportant la dépense de fortes sommes et intéressant la vie et la sécurité des travailleurs. L'échec d'une entreprise, pendant la construction ou après, peut avoir des résultats coûteux et désastreux.

Les heures de travail de l'ingénieur sont d'ordinaire celles de l'usine ou du bureau qui l'emploie; mais les cas d'urgence, les difficultés techniques ou la date limite de la production peuvent exiger de longues heures de travail dans des conditions parfois très difficiles. L'ingénieur doit aussi, par la lecture, en consultant ses collègues ou en assistant à des colloques, se tenir au courant des progrès techniques enregistrés dans son domaine.

SALAIRE ET AVANCEMENT

Chez les ingénieurs de profession, le salaire et les promotions vont généralement de pair avec le degré de responsabilité, le rendement et les qualifications générales. Quelques sociétés accordent autant d'importance à l'ancienneté qu'à la compétence; mais le succès dans le domaine technique est en général bien récompensé.

Les emplois les plus rémunérateurs, dans le génie, sont ceux d'ingénieurs conseils, d'administrateurs et d'entrepreneurs. On verse des salaires élevés aux ingénieurs dans les régions éloignées, probablement pour compenser dans une certaine mesure les conditions de travail et de vie et l'éloignement du foyer.

Les carrières offertes aux ingénieurs de profession sont tellement diverses, selon les talents de chacun et les circonstances, qu'aucun cadre fixe ne peut être considéré comme représentatif. On trouvera une solution au problème dans le compte rendu d'une enquête qui

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[1]Conseil Canadien des Ingénieurs Professionnels, Rapport sur les salaires des ingénieurs professionnels par échelons de responsabilité (annuel), disponible sur demande au Conseil. (Les salaires sont ceux de l'Ontario, du Québec, de la Colombie-Britannique et de l'Alberta.)

Les associations professionnelles et techniques fournissent aussi des services destinés à faire se rencontrer les employeurs éventuels et les ingénieurs à la recherche d'un emploi. Cela comprend le registre des emplois, la publication de listes d'emplois disponibles et, aux réunions des associations, l'établissement de bureaux de renseignement sur les emplois.

Des journaux quotidiens et hebdomadaires, des revues techniques et des brochures que publient certaines entreprises annoncent souvent des occasions d'emploi pour les ingénieurs.[1] Bien des étudiants établissent des contacts grâce à leur emploi en été, s'assurant ainsi une situation permanente pour le jour où ils recevront leur diplôme.

Chaque palier de gouvernement (municipal, provincial et fédéral) emploie un grand nombre d'ingénieurs. Le gouvernement fédéral offre, au moyen de concours par tout le Canada, des emplois d'ingénieurs qui sont annoncés dans les édifices publics, par exemple, les bureaux de poste et les bureaux régionaux du Service national de placement et de la Commission du service civil. Des avis sont, en outre, publiés à intervalles réguliers dans la *Gazette du Canada* et dans les journaux quotidiens.

Les ingénieurs formés à l'étranger

Les ingénieurs qui ont reçu leur formation à l'étranger et qui désirent exercer leur profession au Canada doivent satisfaire aux conditions juridiques de la province où ils veulent s'établir. Ces conditions varient quelque peu d'une province à une autre; on peut obtenir des renseignements précis en s'adressant au Conseil canadien des ingénieurs professionnels ou au secrétaire de l'association provinciale en cause. Les associations provinciales acceptent un grand nombre de diplômes en génie obtenus dans les universités de toutes les parties du monde. Ceux qui n'ont pas un tel diplôme doivent subir des examens écrits.

On signale que les titres exigés au Canada pour exercer la profession d'ingénieur ne sont pas du tout les mêmes que dans le cas du certificat délivré aux ingénieurs des constructions navales et aux mécaniciens de machines fixes.

CONDITIONS DE TRAVAIL

Selon l'occupation du moment et leur spécialité, les ingénieurs de profession travaillent dans des conditions très diverses. Ils peuvent

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[1]Voir aussi *Engineering Careers in Canada*, brochure que publie chaque année l'*Engineering Institute of Canada.*

Association of Professional Engineers of the Province of Ontario,
236 Avenue Road,
Toronto (Ontario).

Corporation des Ingénieurs Professionnels du Québec,
1600, avenue des Pins ouest,
Montréal 25 (Québec).

Association of Professional Engineers of the Province of
New Brunswick,
Room 134, Union Station,
Saint-John (N.B.).

Association of Professional Engineers of the Province of Nova Scotia,
P.O. Box 731,
Halifax (N.S.).

Association of Professional Engineers of the Province of Prince
Edward Island,
242, North River Road,
Charlottetown (P.E.I.).

Association of Professional Engineers of the Province of
Newfoundland,
P.O. Box 31,
St. John's (Newfoundland).

Association of Professional Engineers of the Yukon Territory,
P.O. Box 812,
Whitehorse (Y.T.).

Services de placement

D'après le recensement du Canada, en 1961, la plus grande partie des ingénieurs travaillent moyennant salaire. Pour s'établir dans la profession, le futur ingénieur doit donc se trouver un employeur à qui il doit démontrer sa compétence technique et ses titres personnels. Les ingénieurs et les étudiants en génie qui cherchent de l'emploi peuvent obtenir de l'aide de bien des sources.

On peut obtenir des renseignements sur les occasions d'emploi en s'adressant à la Division des emplois administratifs et professionnels du Service national de placement, qui collabore avec les préposés au placement dans les universités.

Les industries et entreprises privées ont lancé des campagnes de recrutement dans les universités lors de la récente pénurie d'ingénieurs, les diplômés ayant souvent le choix entre deux ou trois emplois différents. Cette situation exceptionnelle ne devrait pas durer, semble-t-il, une fois stabilisées l'offre et la demande d'ingénieurs; mais les employeurs continueront très probablement à aller chercher les bons ingénieurs diplômés dans les universités.

seignements, les étudiants éventuels sont priés de s'adresser au secrétaire de l'association de leur province. (Voir ci-dessous la liste et l'adresse postale des associations.)

LES DÉBUTS DANS LA PROFESSION

Pour devenir ingénieur, il faut avant tout avoir acquis la compétence technique grâce à une formation et à une expérience pratique suffisantes. Pour avoir le titre d'ingénieur professionnel (ing. p.) et le droit d'exercer sa profession, il faut se faire inscrire sur la liste de son association provinciale d'ingénieurs professionnels.

L'inscription à titre d'ingénieur professionnel requiert qu'on ait obtenu au moins le baccalauréat en génie ou ès sciences appliquées d'une université ou d'un collège reconnus, et avoir deux ans d'expérience pratique en génie. On obtient l'équivalent du diplôme en subissant avec succès les examens établis ou reconnus par les associations provinciales. Un ingénieur diplômé, qui acquiert l'expérience requise, peut prendre le titre d'«ingénieur stagiaire», ou, dans le Québec, d'«ingénieur professionnel junior». Les étudiants des cours réguliers, à l'université, ou les personnes qui ont l'intention de subir l'examen écrit établi par une association, peuvent se faire inscrire sur la liste de l'association en tant qu'étudiants. On obtiendra les renseignements relatifs à chaque province en écrivant à l'une des adresses suivantes:

Conseil canadien des ingénieurs professionnels,
116, rue Albert,
Ottawa (Ontario).

Association of Professional Engineers of the Province of British Columbia,
2210 West, 12th Avenue,
Vancouver 9 (B.C.).

Association of Professional Engineers of Alberta,
123 Commercial Building,
10120 Jasper Avenue,
Edmonton, (Alberta).

Association of Professional Engineers of the Province of Saskatchewan,
404, MacCallum Hill Building,
Regina (Saskatchewan).

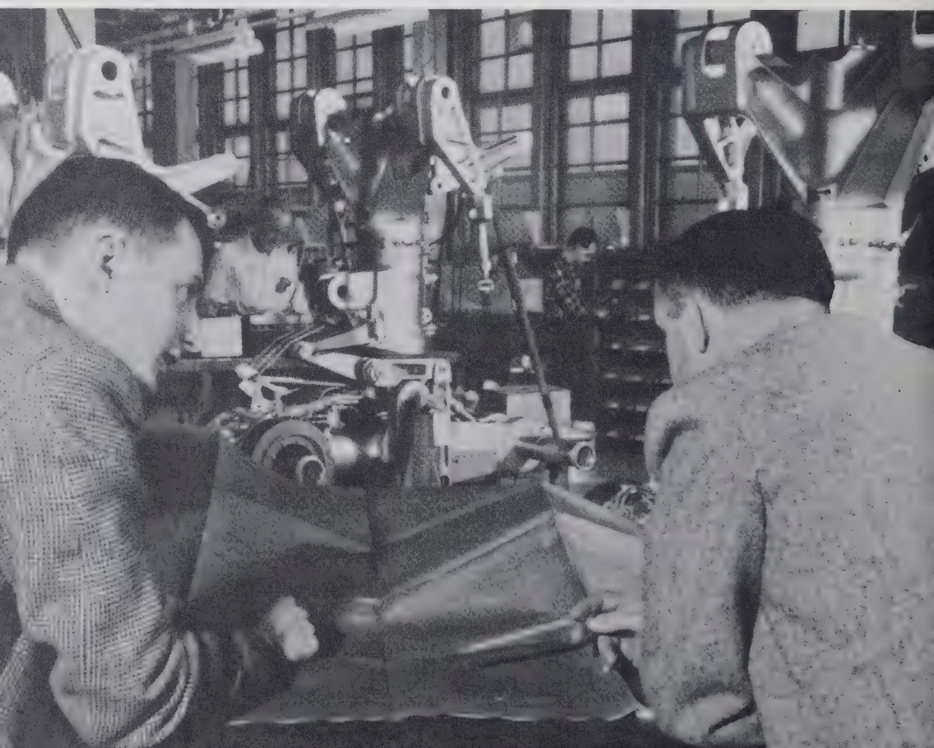
Association of Professional Engineers of the Province of Manitoba,
Room 418, 265 Portage Ave.,
Winnipeg 2 (Manitoba).

cours de formation qu'elles offrent, l'employé touchant son salaire quand même, au sein de l'entreprise ou dans les institutions d'enseignement de la région. Elles préconisent la participation aux réunions techniques et favorisent les comités et colloques de sorte que les jeunes ingénieurs puissent s'intruire au contact des spécialistes dans leur domaine. Bon nombre d'entreprises possèdent des bibliothèques et des laboratoires excellents et elles accordent le temps nécessaire aux travaux de recherche.

Études personnelles

Certaines personnes qui ne sont pas diplômées en génie peuvent faire des études personnelles, subir les examens établis par les associations d'ingénieurs professionnels des diverses provinces et acquérir ainsi la compétence nécessaire pour exercer la profession d'ingénieur (ing. p.). Ces études personnelles prennent plusieurs années; elles ne sont guère tenues en estime avant d'être terminées et seulement un petit nombre d'étudiants les ont réussies. Pour plus amples ren-

Après avoir obtenu son diplôme, le jeune ingénieur a encore beaucoup à apprendre. L'expérience pratique, souvent alliée à la formation au service d'une compagnie, ajoute à sa compétence d'ingénieur professionnel. Photo: ONF



En travaillant pendant les vacances d'été, l'étudiant peut gagner une partie du coût de ses études universitaires. On tend de plus en plus à aider financièrement les étudiants qui le méritent au moyen de bourses, de caisses de prêts, etc. On peut obtenir des renseignements détaillés à ce sujet en consultant le directeur de l'école, le conseiller d'orientation professionnelle ou les annuaires des universités.

Études supérieures

D'après les études faites par la Direction de l'économique et des recherches du ministère du Travail, même si plus de 85 p. 100 des ingénieurs sont bacheliers en génie, moins de 10 p. 100 ont obtenu une maîtrise et pas plus de 1 p. 100 ont un doctorat dans cette science. La maîtrise en génie s'obtient un an après le baccalauréat et le doctorat, deux ans après la maîtrise. Environ 4 p. 100 des ingénieurs n'ont pas de grades universitaires; mais, au moins depuis dix ans, l'admission à la profession a presque toujours comporté un grade universitaire. On tend de plus en plus à exiger non seulement que les ingénieurs aient effectivement suivi les cours d'une institution d'enseignement supérieur, mais aussi qu'ils aient obtenu une maîtrise ou un doctorat. Des relevés du Conseil national de recherches indiquent que le nombre de ceux qui étudient en vue d'obtenir ces grades supérieurs dans les universités canadiennes est passé de 225, en 1953-1954, à 1098, en 1962-1963, c'est-à-dire que le nombre a presque quintuplé depuis neuf ans.

Vacances et emplois à temps réduit

Il est généralement admis qu'avant d'obtenir leur diplôme les étudiants doivent démontrer au collège ou à la faculté de génie qu'ils ont accompli une quantité suffisante de travaux pratiques se rattachant au génie. Les exigences varient depuis les travaux de laboratoire ou sur place, à l'université, jusqu'aux emplois durant les vacances d'été.

Formation dans l'industrie

Presque tous les employeurs confient différentes tâches aux ingénieurs diplômés, afin de leur permettre de se familiariser avec le fonctionnement de l'entreprise. La plupart des grandes sociétés ont des programmes à long terme quant à leur expansion future et elles encouragent leurs employés qui ont de l'ambition à suivre des

La connaissance des deux langues est utile aux ingénieurs canadiens. Dans les institutions de langue française, on se sert de manuels de langue anglaise pour la plupart des cours de génie expérimental, et même pour plusieurs cours théoriques, ainsi que de manuels imprimés en France; mais tous les cours se donnent en français. On veut par là que les étudiants se familiarisent avec les méthodes de génie propres à l'Amérique du Nord, qu'ils seront surtout appelés à appliquer (au lieu des méthodes françaises ou européennes), et les préparer à collaborer et à travailler avec les ingénieurs de langue anglaise. Les ingénieurs dont la langue maternelle est l'anglais trouvent la connaissance du français utile, car bon nombre de ceux avec qui ils travaillent, dans la province de Québec surtout, sont de langue française.

On tend à l'heure actuelle à développer le cours de génie de manière à y inclure plus d'humanités et de sciences sociales, à tel point que certaines universités vont jusqu'à inclure, après quatre années du baccalauréat en génie, une année supplémentaire qui permet aux élèves d'obtenir un baccalauréat ès arts. L'étude de sujets comme les langues, l'économie, l'histoire moderne, les sciences politiques, la philosophie des sciences représente environ 6 p. 100 du temps consacré aux cours réguliers durant les quatre années d'études dans nos universités.

Les premiers diplômes en génie confèrent le titre de bachelier en génie ou de bachelier ès sciences appliquées, selon l'usage établi à l'université. On inscrit sur le diplôme le domaine du génie et les matières dans lesquels l'étudiant s'est spécialisé. On trouvera à la page 50, la liste des cours qui se donnent dans les universités canadiennes en vue d'un baccalauréat en génie.

Droits d'inscription et frais de subsistance

Les droits d'inscription varient de $300 à $700 par année, selon les institutions d'enseignement. Il faut aussi tenir compte des frais de subsistance, surtout si l'étudiant se trouve loin de chez lui. Les frais de subsistance, la chambre, la pension et le blanchissage peuvent varier de $350 à $850 par année de cours, et cela ne comprend pas le coût du transport, des manuels et fournitures scolaires, le vêtement, les amusements et autres dépenses personnelles. Les annuaires des universités fournissent d'ordinaire les renseignements sur les droits d'inscription, le logement disponible et les frais approximatifs.

Introduction au génie: Mécanique, les matériaux et leur résistance, dessin appliqué au génie, les levés (travail sur place), cartographie, problèmes relatifs au génie.

Langues: Composition française (anglaise, dans les institutions de langue anglaise).

Sciences sociales: Histoire moderne, histoire du génie, histoire des sciences, le droit relatif au génie.

La plupart de ces sujets auront été étudiés à la fin de la deuxième année d'université. En troisième et quatrième années, alors que l'étudiant continuera à approfondir certains cours de mathématiques et de sciences fondamentales et les notions générales du génie (cours des première et deuxième années), les cours porteront principalement sur la spécialité que l'étudiant a choisie. Pendant ces dernières années, l'étudiant a aussi la latitude de se spécialiser dans certaines questions du domaine qu'il a adopté, parce qu'on lui permet de choisir parmi les cours facultatifs qui sont donnés. Les annuaires des universités expliquent par le menu les cours obligatoires et facultatifs particuliers à chaque spécialité.

L'arpentage est un art essentiel dans l'étude du génie. Photo: ONF

ÉTUDES ET FORMATION

École secondaire

C'est à l'école secondaire qu'on commence à se préparer à sa carrière d'ingénieur. Le cours de génie est un des plus complets et des plus chargés qui soient à l'université, aussi bien quant aux heures de cours qu'aux tâches assignées, et il exige des efforts soutenus, même de la part des meilleurs étudiants. C'est à l'école secondaire que le futur étudiant en génie doit acquérir les bonnes habitudes de travail qui lui permettront de réussir à l'université.

L'école secondaire fournit la base d'une bonne culture *générale* qui comprend le français, l'anglais, l'histoire, les mathématiques et les sciences.

Pour réussir dans le génie, il importe beaucoup d'avoir une connaissance approfondie des sciences fondamentales (physique et chimie) et une certaine facilité dans le langage de toute science que sont les mathématiques. On souligne l'importance de cette formation dans les conditions d'admission aux cours de génie qu'on pose dans les universités canadiennes. Toutes exigent que l'étudiant ait obtenu au moins 60 p. 100 en géométrie, en trigonométrie, en physique et en chimie, dans les concours de la dernière année d'école secondaire. Certaines universités exigent une moyenne de 66 p. 100.

Université

Au Canada, les ingénieurs doivent d'ordinaire suivre un cours de quatre ou cinq ans à la faculté de génie, une fois terminées leurs études secondaires. La première ou les deux premières années portent habituellement sur les principes généraux du génie; la spécialisation dans un domaine particulier (génie civil, mécanique, électrique, par exemple) ne se fait pas avant la troisième ou la quatrième année. Certains collèges, qui ne confèrent pas le grade d'ingénieur, donnent un cours préparatoire d'un ou deux ans, après quoi l'étudiant fréquente, pour les années de spécialisation, les cours d'une institution qui confère des diplômes. Pour les première et deuxième années après le cours secondaire, un cours type, le même pour tous les domaines du génie, comprendrait les matières suivantes:

Mathématiques: Algèbre, géométrie (analytique et descriptive), trigonométrie, calcul infinitésimal, statistique.

Sciences naturelles: Chimie (organique et minérale), physique (électricité, magnétisme, chaleur, son, lumière), géologie.

Les femmes et le génie

Il doit être évident à quiconque lit cette monographie que rien n'empêche une femme d'être un bon ingénieur. Néanmoins, bien qu'on trouve des femmes dans les principaux domaines du génie, au Canada, le total des femmes ingénieurs est très faible.

Dans l'ensemble, les carrières du génie vers lesquelles s'orientent les femmes sont moins nombreuses que dans le cas des hommes. L'activité féminine se concentre d'ordinaire dans la recherche, les essais, l'inspection, les services de laboratoire et l'enseignement; un petit nombre, s'il en est, s'occupent de la production. Autrement dit, on ne trouvera guère de femmes employées dans des entreprises qui exigent une grande activité mécanique ou manuelle.

Rien, dans la loi, n'empêche les femmes de devenir ingénieurs. Toutefois, certains aspects du génie semblent convenir moins aux femmes qu'aux hommes. D'ailleurs, les employeurs hésiteraient sans doute à envoyer des femmes dans des régions éloignées ou à leur faire courir les périls que rencontrent parfois les ingénieurs.

Il est donc manifeste que la femme ingénieur peut avoir de grands obstacles à surmonter; mais si elle a les aptitudes et l'intérêt nécessaires et si elle est prête à persévérer en dépit des obstacles, elle pourra exercer une carrière satisfaisante.

Bien que le génie soit par tradition une profession d'homme, un bon nombre de travaux de génie peuvent être exécutés par des femmes. Cette jeune femme qui s'est imposée à l'attention du fait qu'elle a été la première diplômée en génie de l'Université McGill depuis dix ans, estime que rien n'empêche un plus grand nombre de femmes d'embrasser cette carrière, pourvu qu'elles aient les aptitudes et l'intérêt requis.
Photo: *Montreal Gazette*

QUALITÉS REQUISES POUR RÉUSSIR DANS LE GÉNIE

Le futur ingénieur doit allier à un grand désir de connaître les lois et les phénomènes de la nature, celui d'en découvrir le secret. Cette prédisposition se manifeste en pratique par le vif intérêt et les aptitudes dont un élève fait preuve dans les sciences à l'école secondaire, par exemple, les mathématiques, la chimie et la physique.

Contrairement au scientifique, qui s'occupe de la connaissance en soi, l'ingénieur, qui s'intéresse aux applications de la science, s'occupe d'ordinaire des questions d'ordre pratique. Mais le futur ingénieur doit être assez imaginatif, car il lui faudra explorer le monde du possible et savoir se représenter ce qu'il cherche à créer quant à la grandeur, à la forme et à la fonction. Il doit être un «rêveur pratique», c'est-à-dire qu'il doit montrer un esprit inquisiteur, analytique et créateur, sans jamais perdre de vue la question du coût. L'ingénieur doit produire des choses utiles du point de vue technique; mais il faut qu'elles soient réalisables du point de vue économique. Le futur ingénieur ne doit donc pas négliger les longues et minutieuses études que comporte inévitablement l'aspect financier de toute entreprise technique.

Un ingénieur doit pouvoir travailler avec les autres, car ses projets sont souvent mis à exécution par d'autres. Il doit posséder les qualités de chef nécessaires pour convaincre et persuader et pour assumer les responsabilités qui incombent d'ordinaire aux ingénieurs. Si un étudiant éprouve de l'aversion pour le travail d'équipe ou la surveillance des travaux, il ferait mieux de s'orienter vers un domaine des sciences physiques.

L'ingénieur doit entrer en rapport avec ses adjoints, ses employeurs et ses collègues, préparer des plans, des devis et des rapports oraux ou écrits. Si la facilité d'expression est jusqu'à un certain point un talent naturel, on peut, par la pratique, cultiver l'art d'écrire et de parler avec clarté.

Comme toutes les sciences pures et les sciences expérimentales, le génie en théorie et le génie en pratique ont des traits communs; tous deux requièrent l'étude, l'esprit d'analyse et la réflexion. L'ingénieur doit non seulement se servir de son talent pour faire face à de nouvelles situations, mais il doit encore se tenir au courant des derniers progrès de la technogénie et des sciences naturelles. Le génie est très dynamique, en ce sens qu'il améliore constamment ses méthodes et ses connaissances en vue de modifier les biens et services qui caractérisent notre économie.

Répartition des ingénieurs d'après les fonctions, dans des spécialités choisies, 1962

	Spécialité										
	Total	Aéronautique	Chimique	Civil	Electrique	Industriel	Physique	Mécanique	Métallurgique	Minies	Pétrolier
	%	%	%	%	%	%	%	%	%	%	%
Recherche et mise en valeur	7	22	16	2	7	4	26	5	25	6	4
Invention	18	21	5	23	20	5	15	22	2	7	3
Production, fonctionnement, entretien	15	9	25	6	13	10	12	18	25	23	47
Construction, installation, érection	11	3	2	25	6	4	1	7	2	6	4
Exploration sur place	2	—	—	1	—	1	2	—	1	8	3
Vente, services, mise en marché, achat	10	4	13	4	12	27	11	15	10	8	6
Enseignement, instruction, vulgarisation	3	4	4	3	4	4	7	3	1	2	1
Administration	26	26	24	29	28	34	17	24	19	30	20
Autres	8	11	11	7	10	11	9	6	15	10	12
Total	100	100	100	100	100	100	100	100	100	100	100

SOURCE: Direction de l'économique et des recherches, ministère du Travail, Ottawa. Les données se rapportent aux 10,399 ingénieurs qui ont répondu à l'enquête du ministère en 1962.

La vente, les services, la mise en marché, l'achat

On a de plus en plus besoin de représentants commerciaux qui possèdent les connaissances suffisantes pour s'occuper des produits techniques. Ces représentants doivent évidemment être de bons vendeurs et posséder une formation technique qui leur permet d'exposer de façon intelligente aux techniciens de l'acheteur éventuel, les principes techniques et les éléments qui composent les produits de la maison qu'ils représentent.

Enseignement, instruction et vulgarisation

Toute profession exige de la part de ses membres le souci de transmettre les connaissances nécessaires à ceux qui ont le talent et la volonté d'apprendre. Les ingénieurs sont souvent appelés à enseigner sur place, à titre de professeurs ou autrement; mais c'est surtout aux universités qu'il appartient, au Canada, d'enseigner le génie fondamental.

A l'université, le professeur de génie est favorisé, car, en plus de la satisfaction qu'il éprouve à transmettre ses connaissances aux étudiants, c'est peut-être là qu'il a le plus de temps et de moyens de se livrer au travail de recherche. Les ingénieurs ont aussi tous les titres nécessaires pour enseigner dans les écoles techniques, où sont formés les techniciens qui aident les ingénieurs dans leur travail. Avec une préparation à l'enseignement, les ingénieurs peuvent enseigner les sujets qui sont à la base de leur profession (mathématiques, chimie et physique) dans les maisons d'enseignement secondaire et les collèges. (Voir OCCUPATIONS AU CANADA, monographie no 44, *Instituteur*.)

Administration (fonctions de directeurs et d'administrateurs)

Dans les travaux de génie, la majeure partie du travail manuel et de routine, est exécuté par de la main-d'œuvre non spécialisée, spécialisée ou semi-professionnelle, à qui l'ingénieur doit déléguer l'autorité et donner des instructions. Ainsi, presque tous les emplois d'ingénieurs comportent la surveillance de certains employés.

Vu que le commerce et l'industrie attachent une plus grande importance à la technique moderne et à la direction scientifique, la formation technique de l'ingénieur acquiert de plus en plus de valeur pour la direction et la gestion des entreprises. L'avancement dans ce domaine conduit à des situations qui comportent de moins en moins de travaux techniques, à mesure que les fonctions administratives prennent de plus en plus d'importance (voir Échelons E et F, page 44) et bon nombre d'ingénieurs diplômés qui remplissent ces fonctions considèrent qu'ils sont d'abord des administrateurs plutôt que des ingénieurs.

des crues, les études sur la profondeur du pergélisol et tout autre travail d'exploration intéressant le génie. Ces travaux supposent d'ordinaire que l'ingénieur doit, souvent en hiver, se rendre dans des régions lointaines et non colonisées et employer tout moyen de transport disponible. L'emploi des instruments électromagnétiques et séismiques, de la perforatrice à diamants et l'examen des carottes font partie de ce genre de travail.

* * *

Les occupations indiquées ci-dessus se rattachent aux aspects purement *techniques* du génie. Elles sont rarement aussi nettement définies que peut le laisser croire le classement précédent. Il y a aussi plusieurs autres occupations qui se rattachent étroitement aux connaissances de l'ingénieur diplômé ou en dépendent.

La *consultation* n'est pas une fonction dans le sens où l'on entend celles dont il a déjà été question ou dont il sera question plus loin; il s'agit plutôt d'un emploi où, en retour d'honoraires, les ingénieurs qui sont à leur compte ou associés à d'autres ingénieurs rendent des services professionnels à leurs clients. Cette profession convient surtout aux ingénieurs qui préfèrent travailler à leur compte plutôt que comme employés. Elle leur donne une indépendance dont ne jouissent pas ceux qui travaillent comme employés; mais elle exige en retour une grande compétence technique et des qualités personnelles de premier plan. Les ingénieurs conseils ont ordinairement un champ d'action plus étendu et varié et il semble que leurs services soient de plus en plus en demande.

Des ingénieurs-conseils offrent une grande variété de services professionnels, moyennant honoraires. Photo: ONF

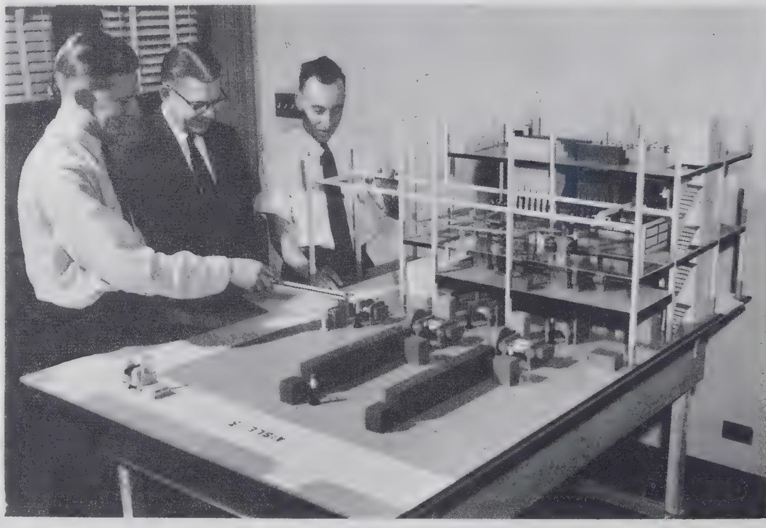
l'exécution des travaux et s'occupent des matériaux employés à la construction; ils assurent l'exécution des travaux selon l'ordre établi et, en général, ils voient à ce que la construction soit exécutée d'après les plans et les étapes prévus.

Bien que l'installation de l'outillage technique soit souvent effectuée par des techniciens et des hommes de métier, les ingénieurs sont appelés à surveiller et à diriger l'installation de l'outillage particulièrement complexe.

Dans le cas d'un outillage complexe, les tâches relatives au fonctionnement et à l'entretien peuvent être confiées à un ingénieur chargé du fonctionnement et de l'entretien. Cet ingénieur verra au bon fonctionnement et au bon rendement de l'outillage, à ce qu'il soit bien entretenu, prévoyant un programme d'inspection, de nettoyage, de remplacement des pièces et de remise au point.

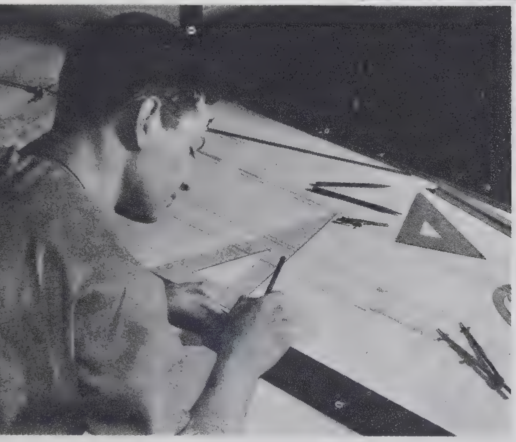
L'exploration sur place

L'exploration sur place au Canada a surtout pour objet la découverte et la reconnaissance de minéraux, mais elle comporte également l'analyse du sol à l'endroit où l'on doit ériger de vastes constructions, les levés hydrographiques pour établir les centrales hydro-électriques, les installations pour l'irrigation ou la répression



Il est évident que les modèles à l'échelle représentent un aspect important de la plupart des projets de travaux de génie. La disposition de cette fabrique de caoutchouc peut être étudiée et modifiée au besoin, avant le début de la construction ou de la mise en exploitation. Photo: *Graetz Bros. Limited,* Montréal

La conception et la construction des machines, des véhicules et de l'outillage modernes exigent des milliers d'heures-ingénieur. Ceci est la salle de dessin d'une grande avionnerie canadienne.



La plupart des devis du génie sont tracés sous forme de dessins à l'échelle. Il est donc important que l'ingénieur puisse dessiner et lire les bleus. Photo: ONF

coût de production et les moyens de vérification, la formation du personnel de production et, depuis quelque temps, l'automatisation ont fait de l'ingénieur d'exploitation un membre important de l'équipe des ingénieurs.

La construction, l'installation

Cette fonction incombe surtout aux ingénieurs chargés des travaux de construction à pied d'œuvre. Ils dirigent et surveillent

nieur chimiste). Les qualités essentielles du chercheur scientifique sont la patience, la ténacité et cette curiosité intellectuelle qui le porte à faire des expériences même après des échecs répétés.

Les recherches d'ordre pratique et le perfectionnement sont plus de nature à donner des résultats tangibles que la recherche fondamentale. On cherche ici à appliquer les connaissances ou principes nouveaux en vue de satisfaire des besoins réels. Il faudra peut-être inventer et mettre à l'essai le prototype de nouveaux produits, appliquer de nouvelles méthodes et techniques d'analyse, de production ou de construction, utiliser de nouvelles matières ou régler des difficultés particulières.

Le génie appliqué à l'invention

Cette technique consiste à appliquer les principes établis du génie à l'invention de composés, de produits, d'outillages, d'ouvrages ou de procédés qui répondent aux exigences pratiques ou au devis descriptif du rendement. Ce domaine touche aux problèmes techniques relatifs à la masse, au poids, à la forme, à la résistance et à l'efficacité, qui doivent être réglés en fonction du prix de revient et qui peuvent se compliquer par suite des exigences du dessinateur industriel qui cherche à plaire aux clients soucieux de l'aspect artistique. L'ingénieur appliqué à l'invention doit être en relations constantes avec le personnel de la recherche et du perfectionnement et consulter souvent les ingénieurs qui seront chargés d'organiser et de diriger la production.

La production, le fonctionnement, l'entretien

Qu'il s'agisse d'un seul objet, un bâtiment, par exemple, ou de la production industrielle d'un grand nombre d'objets identiques, il est indispensable de prévoir, dans l'usine, la disposition méthodique de l'outillage et des machines-outils, l'achat du matériel et la répartition du personnel de la production, afin que l'entreprise se réalise selon un horaire et un ordre préalablement établis.

Les *ingénieurs d'exploitation* s'occupent de l'application des procédés ordinaires de production et des méthodes de travail, de l'aménagement de l'usine et des étapes de la production. Ils font l'essai du produit à intervalles réguliers, se demandant toujours s'il est possible d'améliorer le rendement ou de résoudre les problèmes qui se posent parfois dans le domaine de la production. L'importance de plus en plus grande qu'on attache au rendement, y compris l'étude sur les mouvements et le temps nécessaire pour les exécuter, l'élimination des risques d'accidents ou d'incendie, le registre du

hommes de métier,—électriciens, soudeurs, machinistes et autres artisans,—s'en tiennent aux techniques de leur métier pour la réalisation effective des choses à fabriquer et installer.

Les étudiants qui, après avoir lu cette monographie, ne se sentent pas attirés par le génie, mais qui veulent cependent se livrer à des travaux techniques ou mécaniques, pourraient songer à un travail spécialisé comme celui de technicien ou d'homme de métier. La collection *Occupations au Canada* présente d'autres monographies très fouillées sur ces sujets (voir la deuxième page de la couverture). Les personnes compétentes et possédant les aptitudes voulues peuvent trouver dans ces carrières un emploi satisfaisant et remunérateur. L'ingénieur fera valoir pleinement son esprit créateur et ses connaissances à condition qu'il bénéficie de l'aide d'adjoints de laboratoire, de techniciens, de dessinateurs et d'hommes de métier.

Fonctions

Un ingénieur diplômé,—dans le domaine de la chimie, des mines, de l'électricité ou dans tout autre domaine,—s'attache généralement à une activité ou une fonction particulière. Plus tard, s'il en a la chance, il pourra s'en tenir à l'activité pour laquelle il se sent des aptitudes particulières. Chaque domaine comporte des fonctions diverses, même si certaines formes d'activité appartiennent davantage à un domaine particulier du génie. Ainsi, une assez forte proportion des ingénieurs civils travaillent dans la *construction*, domaine qui emploie également d'autres ingénieurs, mais en nombre beaucoup moindre. Un graphique à la page 31 indique comment les fonctions ci-après se répartissent entre les divers domaines du génie.

La recherche et la mise en valeur

La recherche est indispensable au progrès technique et à l'utilisation des découvertes scientifiques. La recherche fondamentale comporte d'ordinaire l'exploration et l'expérimentation; elle peut ne viser aucune fin immédiate, si ce n'est l'espoir de découvrir de nouvelles techniques, ou avoir pour objet d'améliorer les techniques et les méthodes actuelles. La recherche technique se poursuit dans les universités et les services des gouvernements et, de plus en plus, dans l'industrie.

L'ingénieur qui s'adonne à ce genre de travail doit être très compétent en mathématiques et bien connaître le domaine du génie dans lequel il se spécialise (la chimie, par exemple, dans le cas d'un ingé-

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[1]Pour obtenir de plus amples renseignements, veuillez consulter la monographie no 48: *Les techniciens en sciences et en génie*, de la série OCCUPATIONS AU CANADA.

LE TRAVAIL DE L'INGÉNIEUR

D'une façon générale, l'ingénieur professionnel, utilisant les forces et les ressources de la nature, tâche de créer de nouveaux biens et services qui répondront aux besoins de l'homme.

L'ingénieur s'occupe principalement de l'aspect inanimé, structural et mécanique des choses, n'oubliant évidemment pas leurs conséquences économiques et sociales. Dans le sens où il est un homme de science, il est un «scientifique physicien» qui s'occupe surtout des phénomènes matériels. Toutefois, tandis que le scientifique proprement dit s'efforce d'amener les hommes à prendre davantage conscience de l'univers et des lois de cause à effet, l'ingénieur a surtout pour fonction de mettre les ressources de la science au travail. Il s'intéresse plus à l'utilisation de l'énergie qu'à l'énergie en soi, à l'utilisation des choses plutôt qu'aux choses elles-mêmes. L'ingénieur doit, plus que le scientifique, bien considérer les éléments humains, économiques et financiers que comporte toute entreprise.

Normalement, l'ingénieur ne travaille pas seul. Il fait partie d'une équipe qui comprend d'autres ingénieurs, des techniciens et des hommes de métier. Un groupe nombreux de techniciens[1] possédant l'intelligence voulue et une formation technique au-dessus de la moyenne et une vaste expérience, rend de précieux services aux ingénieurs, accomplissant souvent un travail d'une nature très complexe qui se rapproche du travail de l'ingénieur diplômé. Les

[1]Voir OCCUPATIONS AU CANADA, Monographie 14, *Emplois miniers.*

L'ingénieur fait partie d'une équipe qui comprend d'autres ingénieurs ainsi que des techniciens et des ouvriers de métier.
Photo: *de Havilland Aircraft of Canada Limited*

la forme et la qualité. S'ils s'occupent surtout de concentrer la partie utile d'un minerai sous une forme et une qualité utilisables, ils appartiennent à la division de la métallurgie *extractive* ou de *transformation.* Les ingénieurs de la division *physique* changent les matières en produits ouvrés.

Depuis de nombreuses années, le Canada possède une industrie importante de transformation des minerais métalliques et non métalliques et, de nos jours, notre pays se range parmi les principaux producteurs mondiaux de nickel, d'aluminium, d'or, de magnésium, de zinc, d'argent, de cuivre, de plomb, d'amiante, de fer et d'uranium. Jusqu'en 1939, les régions de Sudbury en Ontario, de Noranda et de Thetford-Mines dans le Québec, et de Kootenay en Colombie-Britannique, fournissaient la majeure partie de notre production. Depuis lors, la découverte et l'exploitation de nombreux gisements, l'accroissement des débouchés et les progrès techniques ont porté notre industrie de transformation des minéraux au degré important qu'elle possède actuellement dans l'économie canadienne.

Le travail de l'ingénieur métallurgiste est fondé sur la connaissance de la chimie minérale et de la physique des solides. L'étudiant doit être bien doué pour la chimie, la physique et les mathématiques et s'intéresser aux métaux et à leurs emplois. L'ingénieur métallurgiste s'est assez facilement adapté à des tâches connexes que remplissaient d'ordinaire les chimistes, les ingénieurs chimistes et les physiciens.

Le génie céramique est une branche fort spécialisée encore que très connexe du génie métallurgique, qui consiste à récupérer et transformer les minéraux non métalliques. Les méthodes et l'outillage sont les mêmes que dans le cas des métaux. Les genres de produits courants dans l'industrie céramique sont l'argile ou le schiste de construction, les briques et les blocs, l'émail à porcelaine, les briques réfractaires pour revêtir la paroi des fours à haute température, la poterie et la faïence fine, le verre, les abrasifs servant au meulage et au finissage, le ciment, la chaux et le gypse.

Des ingénieurs en métallurgie physique surveillent le réchauffage d'un lingot dans le puits chauffé avant son passage dans les laminoirs. Photo: ONF

Le domaine de l'*ingénieur métallurgiste* se divise en quatre secteurs:

1. L'extraction, la concentration, le traitement et le raffinage des métaux.
2. L'adaptation des métaux et alliages aux besoins de l'industrie.
3. La fabrication et le moulage des métaux et alliages dans des formes utiles à l'industrie.
4. L'étude des terrains, des minerais, des métaux et alliages, de leur structure et constitution, de leurs propriétés physiques et techniques; le classement, la combinaison ou le traitement des métaux pour en améliorer la qualité.

Les ingénieurs métallurgistes conçoivent et dirigent la construction et le fonctionnement des appareils, machines ou autre outillage destinés à rechercher les propriétés des minéraux métalliques et de leurs éléments utiles, ou à concentrer ces matières et à en modifier

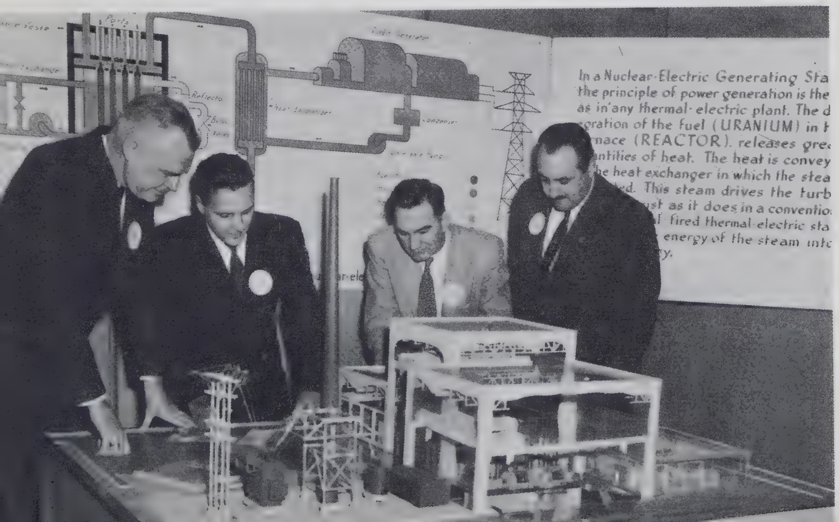
LE GÉNIE PHYSIQUE

L'*ingénieur physicien*, grâce à la théorie et aux connaissances que le physicien a acquises et formulées, conçoit les machines et procédés qui rendent cette théorie et ces connaissances utiles. Les applications industrielles de la physique permettent de découvrir ou d'améliorer des biens et services, de faire des découvertes physiques qui, une fois conçus les procédés et les machines, grâce à l'aide de l'ingénieur, sont nécessaires au progrès dans d'autres sciences naturelles. La nature et les propriétés de la lumière, de l'électricité, des aimants, de la chaleur, du son et de la matière sont du domaine immédiat de l'ingénieur physicien, ce qui comprend aussi la physique atomique ou nucléaire, l'étude spécialisée des fluides, l'optique, l'acoustique, l'aéronautique et la géophysique.

Ces ingénieurs se consacrent d'ordinaire à des recherches fondamentales ou au travail initial en vue de régler un problème déterminé. Ils étudient souvent de nouvelles conceptions ou des domaines inexplorés, ou encore des problèmes qu'il faut aborder d'une façon toute nouvelle. Il se peut qu'on doive inventer les machines et l'outillage nécessaires pour effectuer les recherches qui permettent à l'homme de connaître davantage les phénomènes de la nature. L'industrie a besoin des ingénieurs physiciens pour le travail de découverte et de production, dans le cas de produits qui exigent le recours à des méthodes très techniques. Divers laboratoires des gouvernements et de l'industrie emploient des ingénieurs physiciens pour la recherche abstraite ou d'ordre pratique dans le domaine du génie.

L'étudiant qui aime la physique et les mathématiques, mais qui s'intéresse moins à la fabrication des objets, devrait examiner les possibilités que lui offrirait un diplôme spécialisé en sciences dans le domaine de la physique pure. Durant le cours de génie, on insiste plus sur les aspects pratiques des mathématiques et de la physique que dans le cours de sciences.

L'utilisation de l'énergie nucléaire à des fins pacifiques pose de nombreux problèmes aux ingénieurs. Photo: *Gilbert A. Milne & Co., Toronto*



LE GÉNIE AGRICOLE

De l'application de la technologie du génie à l'agriculture est né un nouveau type de spécialiste: *l'ingénieur agricole*. Il allie la connaissance des sciences agricoles à une formation dans quelque branche du génie mécanique, chimique, électrique ou civil. Suivant sa formation technique, son travail peut porter sur un ou plusieurs sujets: la machinerie agricole, les bâtiments de ferme, l'irrigation, la conservation des sols, le défrichement, le drainage et la régénération des terres, l'électrification rurale, etc.

Les personnes possédant cet ensemble de sciences et de technologie du génie travaillent dans les universités et les services gouvernementaux, où elles s'occupent de recherche, d'enseignement et de vulgarisation, ou dans les industries privées qui se spécialisent dans les produits agricoles ou qui desservent l'industrie agricole.

La formation universitaire varie. On l'acquiert ordinairement dans une faculté d'agriculture et elle peut mener à l'obtention du baccalauréat en sciences avec spécialisation en génie agricole ou au baccalauréat en génie agricole. Les aspirants feraient bien de s'assurer auprès du secrétariat de l'université que les cours offerts à cette institution correspondent bien à leurs projets de devenir ingénieurs professionnels.

LE GÉNIE FORESTIER

Les forêts et l'industrie forestière du Canada jouent un rôle essentiel dans l'économie nationale. La superficie totale de nos forêts est de plus de 1,700,000 milles carrés, dont près de 60 p. 100 contiennent du bois marchand.

Les *ingénieurs forestiers* s'occupent principalement de la conservation des forêts et de la coupe du bois. Il leur faut des connaissances en génie pour construire des routes en forêt, adapter les cours d'eau au transport des billes, construire des barrages et des ponts et résoudre un bon nombre d'autres problèmes relatifs à la coupe, à la sortie et au transport du bois des forêts aux marchés. Les ingénieurs forestiers passent beaucoup de temps à dresser des cartes et des inventaires de domaines forestiers et sont chargés d'établir un programme de coupe de manière à assurer la continuité d'une récolte qui prend jusqu'à un siècle à mûrir. L'importance accrue qu'on accorde à la gestion, à la conservation et à l'utilisation scientifiques va étendre le rôle futur de l'ingénieur dans l'industrie forestière du Canada.

La distinction entre le génie forestier et les sciences forestières n'est pas toujours très nette; les étudiants feraient bien d'examiner leurs intérêts principaux en tenant compte des qualités nécessaires au succès, résumées à la page 32, avant de choisir un cours de sciences forestières en vue d'une carrière d'homme de science ou d'ingénieur. Ils devraient aussi s'assurer que l'université qu'ils choisissent offre un cours de sciences forestières en rapport avec leurs intérêts.

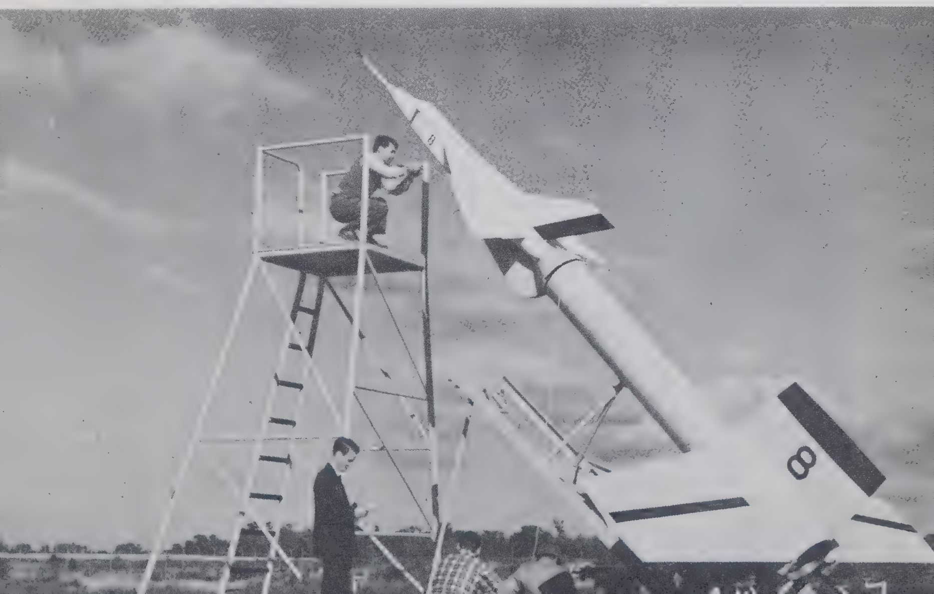
LE GÉNIE AÉRONAUTIQUE

Les ingénieurs de l'aéronautique se spécialisent dans le dessin, l'essai et la construction d'avions et, récemment, de missiles téléguidés, de fusées, de satellites et de véhicules spatiaux.

Si l'on tient compte de sa population relativement peu nombreuse, on peut dire que le Canada a apporté une contribution importante dans le domaine de l'aéronautique et de la technologie de l'espace. La première grande initiative a été la recherche en aérodynamique menée dans le tunnel aérodynamique qu'avait construit M. W. R. Turnbull, au Nouveau-Brunswick, avant même que les frères Wright tentent leur première envolée en 1903. Par la conception et la production de moteurs à réaction, de charpentes et d'armement d'avions, par la haute qualité de ses équipes d'ingénieurs et par sa production au cours des années, le Canada est reconnu dans le monde entier. Le travail en aéronautique s'est étendu à la technologie de l'espace avec la création de la fusée de recherche de haute altitude *Black Brant* et du satellite Alouette, qui ont tous deux très bien réussi.

L'aéronautique moderne se fonde largement sur le génie mécanique et le génie physique en même temps que sur la spécialisation en aérodynamique. L'Université de la Colombie-Britannique, l'Université Laval et l'Université McGill offrent des cours facultatifs sur ce sujet. L'Université de Toronto offre des cours, aux niveaux du baccalauréat et des grades supérieurs, en génie aéronautique-astronautique en relation avec le cours de génie physique.

L'ère spatiale ouvre des horizons nouveaux et prometteurs à l'ingénieur. Photo: *Avro Aircraft Limited*



LE GÉNIE PÉTROLIER

Depuis quelques années, l'industrie canadienne du pétrole a pris une expansion remarquable qui a eu d'importantes répercussions sur notre économie. L'activité la plus importante jusqu'ici a été la recherche, la découverte et l'exploitation des riches gisements pétroliers de l'Ouest du Canada. Le génie pétrolier est un secteur du génie minier; mais il est devenu une spécialité qui exige une formation sensiblement différente.

L'ingénieur des pétroles doit s'occuper de tout ce qui a trait à la rencontre du pétrole: méthodes d'exploration, réserves et concessions, délimitation du champ, espacement des puits, outillage et procédés de forage, examen des carottes, parachèvement des puits, pompage, surveillance des puits, conception et construction des moyens d'emmagasinage et de transport et, de façon générale, estimation des gisements de pétrole et de gaz. Le génie pétrolier comporte une spécialisation: l'estimation des réserves de pétrole et de gaz pour alimenter la production future.

Dans le domaine du génie pétrolier, il faut distinguer entre les techniques d'extraction du pétrole et les techniques de raffinage. Le raffinage du pétrole est l'application du génie chimique au traitement des pétroles. Quiconque s'intéresse à cette branche devra suivre le cours régulier de génie chimique, qui comprend la chimie organique et les méthodes de classement et de raffinage du pétrole brut.

Photo: ONF par B. Beaver

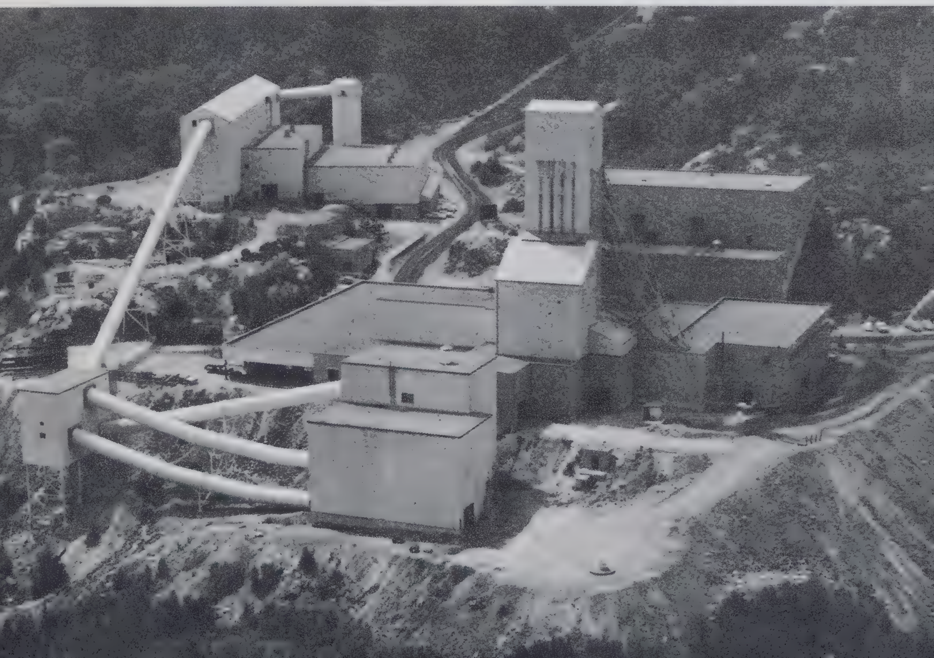
teindre rapidement les postes de direction. L'ingénieur des mines aspire naturellement aux postes de commande de l'industrie minière; les perspectives de réussite sont bonnes pour les personnes compétentes, puisque la plupart de ceux qui occupent ces postes ont le grade d'ingénieur des mines.

L'ingénieur des mines trouvera peut-être du travail dans des entreprises qui fabriquent de l'outillage, des machines et moteurs destinés à l'extraction minière. Les services de l'État font des recherches sur les minéraux et les méthodes d'extraction et ils confient à des ingénieurs des mines l'application des lois relatives aux mines. On considère l'ingénieur des mines comme ayant toute la compétence voulue pour s'occuper de certains aspects de l'industrie de la construction, par exemple, les excavations et le percement des tunnels.

Les ingénieurs des mines qui occupent des postes de direction se voient souvent en face de responsabilités beaucoup plus vastes que la simple conduite de leur entreprise. Il leur faudra peut-être voir à l'organisation et à l'établissement d'une assez importante collectivité minière, ainsi que de services connexes et autres installations sur l'emplacement d'un camp en pleine forêt.

Le travail des *ingénieurs géologues* se rattache étroitement au génie minier, puisqu'il a trait à l'exploration sur place, à la découverte et à l'étude des gisements. Ces ingénieurs doivent décider si un gisement a assez de valeur pour être exploité sur le plan commercial et examiner d'autres éléments, par exemple, les possibilités d'accès et les disponibilités en fait d'eau et d'énergie motrice.

Photo: Le ministère des Mines et des Relevés Techniques



LE GÉNIE MINIER

L'*ingénieur des mines* s'occupe de la production de minéraux, de pétrole et de gaz naturel et d'autres éléments utiles qu'on extrait de la terre. Au Canada, son vaste champ d'action comprend l'exploration des territoires inconnus, la mise en valeur des gisements prometteurs, la surveillance de l'extraction à ciel ouvert ou souterraine, le broyage et autres premiers traitements du minerai et, enfin, les travaux qui s'échelonnent depuis la mine jusqu'au marché.

Les produits miniers se divisent principalement en matières:
- Métalliques (par exemple, le fer)
- Non métalliques (par exemple, l'amiante)
- Combustibles (par exemple, le pétrole)
- Matériaux de construction (par exemple, le gravier)

Il n'est pas rare qu'un ingénieur des mines se spécialise dans un minerai (par exemple, la houille), dans un genre de minerais (les minéraux non métalliques) ou dans certains domaines de l'extraction minière (par exemple, les machines à creuser et à transporter ou les éléments de puissance motrice et l'outillage de climatisation).

Les ressources minérales sont l'un des principaux avoirs du Canada, dont la valeur de la production n'est dépassée que par celle des industries forestières et agricoles. Nos ressources minérales abondantes et diverses non seulement alimentent nos usines de transformation et de fabrication, mais elles sont aussi très importantes en tant que réserves de matières et de denrées que le pays peut échanger sur les marchés mondiaux contre les multiples produits des autres pays dont il a besoin. De 1947 à 1958, le Canada a plus que triplé sa production minérale; on découvre constamment de nouveaux gisements et, chaque année, on commence à exploiter de nouvelles mines. Cependant, une petite partie seulement des vastes espaces du Canada a été explorée au point de vue des ressources minérales.

Jusqu'à une époque relativement récente, les exploitants de mines préféraient les hommes formés sur place aux diplômés des universités. La nécessité de concurrencer quant à l'efficacité et à la sécurité et de réduire le dur travail matériel a nécessairement obligé à rendre l'extraction minière de plus en plus mécanisée et complexe. Cependant, le coût de la main-d'œuvre est toujours le poste le plus important des dépenses dans l'industrie minière, et la plupart de ceux que doit diriger l'ingénieur des mines ont consacré leur vie à l'extraction minière. Aucune formation théorique ne peut remplacer la connaissance du travail acquise dans la mine. L'ingénieur des mines devra probablement commencer au bas de l'échelle, à la mine, comme ingénieur géographe ou échantillonneur;[1] mais ses connaissances théoriques et pratiques devraient lui permettre d'at-

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[1]Voir OCCUPATIONS AU CANADA, Monographie 14, *Emplois miniers.*

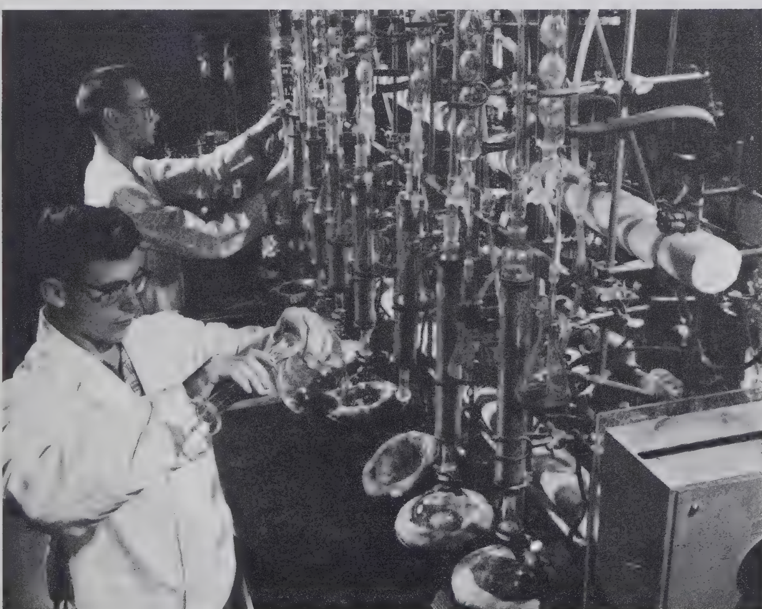
LE GÉNIE CHIMIQUE

La fonction de l'*ingénieur chimiste* illustre bien le lien qui existe entre la science et la denrée produite. Cette fonction comporte l'adaptation du travail de laboratoire du chimiste à une production commerciale massive, efficace et à faible prix de revient. Ce travail comprend la conception, la construction, la direction et le fonctionnement d'usines et d'appareils qui permettent de disposer autrement les éléments de la nature de façon à produire des substances améliorées ou entièrement nouvelles et de faire l'épreuve chimique des produits.

On ne peut établir nettement le domaine du genie chimique. L'apport de la chimie à l'économie actuelle est universel. Sans la chimie, peu de biens et de services seraient vraiment ce qu'ils sont et dans bien des cas leur existence même dépend de la chimie. Au Canada, la chimie prend un essor rapide dans le domaine des textiles synthétiques, des matières plastiques, des contre-plaqués, du conditionnement des aliments, des produits pharmaceutiques, des peintures et des matériaux de construction. Étant donné les multiples applications de la chimie, les ingénieurs chimistes sont très en demande. L'ingénieur chimiste est appelé à travailler dans toute industrie de transformation où la chimie joue un rôle ou dans laquelle la connaissance de la chimie et du génie est précieuse, aussi bien que dans les industries chimiques proprement dites.

L'étudiant orienté vers la chimie doit être sûr qu'il veut s'adonner au génie avant d'opter pour le génie chimique. S'il préfère l'expérimentation et la recherche à la production, il devrait plutôt songer à devenir un chercheur scientifique en chimie.

Photo: ONF par Malak



LE GÉNIE MÉCANIQUE

La spécialité des *ingénieurs mécaniciens* consiste à concevoir et surveiller la fabrication, la vente et le fonctionnement des machines et appareils qui servent à produire, transporter ou utiliser l'énergie.

Le génie mécanique comprend quatre divisions:

Les génératrices d'énergie:

Moteurs à vapeur, moteurs diesel et autres moteurs à combustion interne, moteurs actionnés par l'énergie marémotrice, aéromoteurs et turbines hydrauliques ou turbines à gaz.

Les appareils de transmission d'énergie et de manutention:

Convoyeurs, engrenages, transmissions et appareils servant à transmettre la chaleur.

Les moteurs et appareils utilisant de l'énergie:

Machines-outils, ventilateurs et autres appareils, fours industriels, automobiles, locomotives, avions et navires.

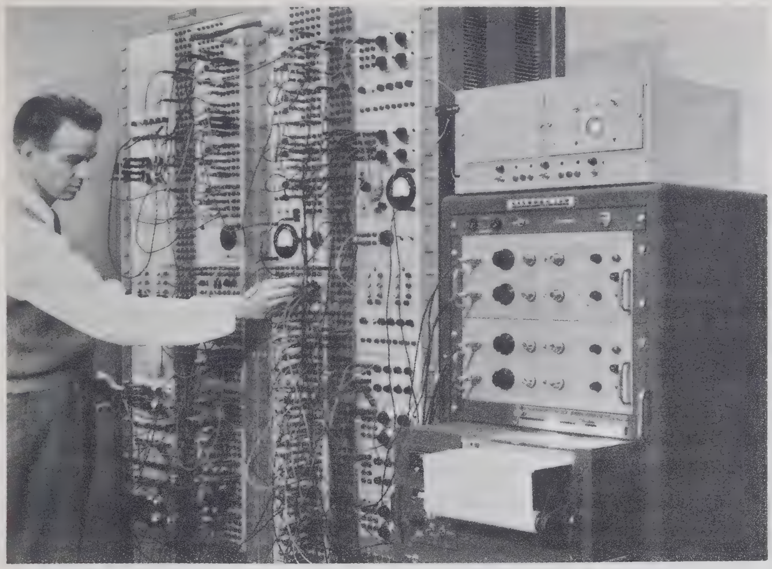
Le chauffage et la ventilation:

Climatisation.

Les ingénieurs mécaniciens s'occupent de tant de domaines et leurs services sont si universellement nécessaires à la source de tous les travaux de génie qu'il n'y a pas à être surpris si un grand nombre d'industries de toutes les régions du Canada réclament ces services. L'expansion de notre industrie lourde dans la transformation des métaux, la fabrication des machines et dans d'autres domaines depuis la seconde Grande Guerre rend de plus en plus grand le besoin d'ingénieurs mécaniciens.

Étant donné que les ingénieurs mécaniciens travaillent surtout dans les industries de fabrication ou s'occupent du fonctionnement et de l'entretien des centrales, ils habitent généralement dans les grands centres ou dans leur voisinage. Souvent, ils ont à diriger et prévoir le travail des autres à l'usine. Qu'il s'agisse de production électrique, chimique ou métallurgique, le travail de l'ingénieur mécanicien est toujours en relation étroite avec tous les autres domaines du génie. Tôt ou tard, l'ingénieur doit connaître les différents genres de machines-outils, afin de pourvoir à l'aménagement approprié des ateliers aux fins de la production.

Les *ingénieurs industriels* se spécialisent dans la production (voir page 26), surtout dans l'analyse industrielle et technique. La formation dans ce domaine est relativement récente au Canada et ce n'est que récemment que l'Université de Toronto l'a mise au programme d'études.



Un ingénieur dispose une machine électronique à analogie pour faire une expérience sur un appareil d'extraction. Les conditions réelles simulées en rapport avec cet appareil peuvent être étudiées et les problèmes écartés avant de procéder à la conception, à la fabrication ou à l'installation de l'outillage.
Photo: *Canadian General Electric*

Il y a au Canada un grand nombre d'importantes entreprises productrices d'électricité, dont le fonctionnement exige les services de nombreux techniciens en électricité. Les moteurs mus au moyen de l'énergie hydraulique ou de la vapeur ou les moteurs diesel servent tous à produire de l'électricité; mais l'énergie hydraulique est de beaucoup la plus utilisée. Cela signifie d'ordinaire qu'il faut aménager des lignes de transmission à haute tension pour amener l'énergie aux centres de charge. On a aménagé une centrale atomique d'électricité, en Ontario, et d'autres sont projetées.

L'électrification de l'industrie canadienne est très poussée et, même si les fabricants d'appareils électriques emploient assurément un grand nombre d'ingénieurs électriciens, on requiert aussi leurs services dans nombre d'autres secteurs industriels. La quantité d'énergie utilisée et la complexité des réseaux électriques des papeteries, des aciéries et des filatures d'aujourd'hui, des fabriques de produits chimiques et d'automobiles, des mines, et le reste, sont telles que la conception et le fonctionnement de ces réseaux nécessitent les services des ingénieurs électriciens.

LE GÉNIE ÉLECTRIQUE

Le domaine de l'*ingénieur électricien* embrasse les réseaux, appareils et accessoires électriques qui permettent de produire, transporter et exploiter l'électricité pour l'éclairage, le chauffage, la force motrice, les communications et l'électrothérapie.

Le génie électrique comprend quatre divisions:

La force motrice:
Production, transport et distribution de l'énergie électrique; conception, fabrication et fonctionnement des appareils et de l'outillage électriques (lignes de transmission, transformateurs, sous-centrales électriques, moteurs industriels, génératrices, outillage électrochimique et dispositifs électriques de mesure et de réglage utilisés dans d'autres produits industriels, par exemple, les avions, les bateaux, les locomotives électriques, les automobiles; d'autres usages dans les maisons et pour le transport et l'industrie.

Les communications:
Téléphone, télégraphe, radar, enregistrement sonore, radio, télévision, téléphotographie, télétype.

L'éclairage:
Éclairage des maisons, des bureaux, des usines, des écoles, des rues, et le reste.

L'électronique:
Toute électrotechnique qui comporte le passage de l'électricité dans des tubes à vide, des tubes à gaz à faible pression ou des semi-conducteurs massifs (transistrons) et qui fournit un courant réglé d'électrons. On comprend ici le mesurage, la mise en circuit, la signalisation et la commande par impulsions électroniques des opérations de fabrication et de nombreux appareils de tous genres.

La fabrication de pièces électroniques au Canada remonte à la production de postes récepteurs de radio, immédiatement après la première Grande Guerre. En 1923, plusieurs sociétés importantes se livraient à cette industrie et, vers 1937, plus de 80 p. 100 des postes récepteurs de radio canadiens étaient fabriqués au Canada. Lorsque s'est déclarée la seconde Grande Guerre, le Canada était en mesure de jouer un rôle de premier plan dans les découvertes et la fabrication des appareils électroniques destinés aux armées alliées.

L'essor de l'industrie électronique du Canada s'est maintenu après la guerre, malgré la forte concurrence d'autres pays. Aujourd'hui, plus de cent entreprises électroniques produisent, au Canada, tous les genres d'appareils destinés à agrémenter le foyer ou destinés au commerce, à l'industrie ou à l'armée et, chaque mois, l'on fait dans ce domaine des découvertes qui accroissent l'utilisation des pièces électroniques et des produits ouvrés.

LE GÉNIE CIVIL

L'expression «ingénieur civil» s'applique maintenant à celui qui s'occupe de construire ou d'améliorer des ouvrages fixes représentant des «biens-capitaux» plutôt que des «biens de consommation», qui s'occupe de faire des levés et de refaçonner les particularités géographiques de la terre.

Le génie civil comprend quatre divisions:

Le transport:
Routes, rues, chemins de fer, viaducs surélevés, pipe-lines et aéroports.

Les techniques de la construction:
Ponts, tunnels, métros, usines, centrales d'énergie électrique, tours de lignes de transmission d'électricité.

L'hydraulique:
Barrages, installations pour la répression des crues ou pour l'irrigation, ports, canaux, réservoirs.

L'hygiène publique:
Eau potable, système d'écoulement des eaux, système d'épuration des matières d'égout.

La structure du terrain est un facteur si important dans la plupart des entreprises de génie civil que de nombreux ingénieurs civils sont devenus spécialistes des sols. D'autres spécialités visent les *services municipaux*, *l'urbanisme* et *la circulation des véhicules*. L'arpentage, ou levé de plans, constitue un domaine distinct, bien qu'il soit une partie importante de tous les travaux de génie civil.

L'ingénieur civil doit souvent travailler à l'extérieur. Son travail exige une grande activité et il a bien des fois la responsabilité d'un grand nombre de travailleurs. Les ingénieurs civils mènent souvent une vie de nomade. On les emploie à des entreprises de construction dans des régions éloignées; même dans des régions habitées, où ils peuvent être employés à une vaste entreprise pendant plusieurs années, bon nombre d'ingénieurs devront aller ailleurs une fois les travaux terminés. A cause de l'immensité du Canada, l'ingénieur doit voyager beaucoup pour accomplir son travail. L'ingénieur se plaît davantage dans sa profession s'il est robuste, s'il aime à travailler en équipe et à diriger des hommes et s'il consent au moins durant les premières années de sa carrière à travailler à divers endroits du Canada, sur les lieux mêmes des entreprises.

Le domaine du génie civil est si vaste qu'un grand nombre de spécialités qu'il comporte, par exemple, les travaux de charpente, les routes, l'hydraulique, les chemins de fer et les entreprises relatives à l'hygiène et à la santé publique, constituent maintenant des domaines distincts dans lesquels les étudiants peuvent se préparer en suivant des cours réguliers ou post-universitaires.

PRINCIPAUX DOMAINES DU GÉNIE

Autrefois, le travail de l'ingénieur consistait surtout à faire des routes, des canaux, des fortifications et des engins de guerre. On en a un exemple dans le canal Rideau, que le colonel John By, du Génie, a aménagé de 1826 à 1832 pour «assurer le transport militaire au-delà des eaux frontalières américaines». Tous les ouvrages de génie qui n'étaient pas de nature militaire étaient en conséquence appelés des travaux du génie «civil». A mesure que s'est accrue la complexité de la technologie moderne, les ingénieurs «civils» ont eu tendance à prendre le nom du domaine technique dans lequel ils sont spécialisés, par exemple, la chimie, l'électricité, la mécanique, et le reste. Il y a encore du chevauchement d'un domaine à un autre, de sorte qu'aucun ingénieur ne peut s'en tenir à sa spécialité à l'exclusion de toutes les autres.

Un ingénieur civil vérifie la marche des travaux à une nouvelle fabrique de ciment en voie de construction. Photo: NFB

A l'étude d'un modèle réduit du projet d'aménagement hydro-électrique et de canalisation du Saint-Laurent, l'une des grandes entreprises modernes de travaux de génie. Photo: Hydro-Ontario

tous les domaines du génie. Le Conseil Canadien des Ingénieurs Professionnels, établi en 1936, groupe les Associations d'ingénieurs dont relève l'exercice de cette profession dans chaque province et représente la profession sur le plan fédéral.

Les ingénieurs étrangers continuent à essayer de faire leur carrière au Canada; mais les moyens de formation dont disposent les jeunes Canadiens se sont rapidement accrus et au moins trente-deux collèges et universités offrent maintenant des cours d'une année et plus en vue de l'obtention d'un grade dans les nombreux domaines du génie. Il est difficile de donner le nombre exact des ingénieurs du Canada. De nombreux ingénieurs occupent des emplois qu'on ne rattache pas d'ordinaire au génie, par exemple, l'administration (voir page 30). En 1951, le ministère du Travail estimait à 35,000 le nombre de ceux qui, au Canada, avaient le grade d'ingénieur ou son équivalent. En 1963, il y en avait, croyait-on, près de 50,000.

HISTORIQUE ET IMPORTANCE DU GÉNIE

Toute création de l'homme (une route, un pont, une automobile, un nouveau produit chimique, et même une souricière perfectionnée) relève au fond du génie, en ce sens que la conception, la réalisation et, dans certains cas, la commercialisation d'un produit sont effectuées ou orientées par des ingénieurs.

Vu que l'homme est naturellement créateur, que, grâce aux matériaux disponibles, il se crée un monde plus confortable, les ingénieurs existent depuis longtemps. Canaux, routes, fortifications et monuments, qui, dans bien des cas, datent de milliers d'années, témoignent de l'héritage des ingénieurs d'aujourd'hui.

Dans une société très complexe et très technologique comme la nôtre, le travail de l'ingénieur touche directement ou indirectement presque tous les aspects de la vie quotidienne.

Le génie au Canada

Le Canada est un pays jeune; sa croissance et sa mise en valeur ont suscité et suscitent encore de nombreux problèmes. Ce pays aux ressources si riches et si abondantes comporte aussi des difficultés dues aux grandes distances, aux régions hérissées de montagnes, aux hivers très rigoureux et à l'éloignement des marchés mondiaux.

Dès le commencement, la mise en valeur du Canada a été une entreprise colossale dans le domaine du génie, comportant des ouvrages comme les deux réseaux de chemin de fer continentaux et l'aménagement de routes utilisables par tous les temps, l'établissement d'une voie navigable qui permet aux navires de long cours de pénétrer au coeur du continent, l'installation d'un système continental de communications micro-ondes à canaux multiples, l'exploitation des ressources forestières, minérales et hydrauliques, et l'établissement d'une importante industrie de fabrication qui grandit rapidement.

Jusqu'à la fin du XIX^{e} siècle, ces tâches ont été accomplies par des ingénieurs formés en Grande-Bretagne, aux États-Unis et dans diverses institutions d'Europe. L'Université du Nouveau-Brunswick, l'Université McGill, l'École Polytechnique de l'Université de Montréal et l'Université de Toronto ont donné les premiers cours de génie. La première Association d'ingénieurs de profession a été établie au Canada en 1887, sous le nom de *Canadian Society of Civil Engineers;* en 1918, elle est devenue l'*Engineering Institute of Canada*, élargissant le champ de son activité de façon à englober

CARRIÈRES DANS LE GÉNIE

L'ingénieur professionnel est un investigateur scientifique qui applique au domaine pratique les connaissances révélées par la science. Grâce aux méthodes que les praticiens de l'art du génie ont mises au point au cours des siècles, il utilise les matériaux et les forces de la nature et contribue à organiser le travail de l'homme de façon à lui faire produire les biens et services qui satisfont à ses besoins. L'ingénieur est l'associé principal, —il en est souvent le chef,—d'une équipe de travailleurs qui s'occupe des problèmes d'ordre technique que présente toute entreprise où entrent en jeu les sciences physiques.

Photo: ONF

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TABLE DES MATIÈRES

AVANT-PROPOS

Depuis quelques années, la demande de renseignements sur les occupations au Canada augmente constamment. Cette demande vient de jeunes qui doivent se choisir une carrière et s'y préparer; elle vient aussi de parents, d'instituteurs et d'orienteurs, de travailleurs qui désirent changer d'emploi, de fonctionnaires du Service de placement, de directeurs de personnel, de dirigeants syndicaux, d'immigrants éventuels et de divers autres milieux.

La série de monographies intitulée *Occupations au Canada* a pour but d'aider à répondre à cette demande. Chaque brochure décrit, entre autres choses, la nature d'une occupation ou d'un groupe d'occupations, les conditions d'admission et de formation, les conditions de travail et les perspectives d'emploi.

La série a été préparée avec le généreux concours de représentants du patronat, de syndicats ouvriers et d'associations professionnelles. Il y a lieu de mentionner également la bienveillante collaboration de la Commission d'assurance-chômage, de la Direction de la formation technique et professionnelle du ministère du Travail et du Bureau fédéral de la statistique.

Les renseignements concernant les occupations ont tendance à devenir désuets à cause des changements qui se produisent dans les conditions économiques, dans la technologie industrielle et dans la structure des salaires et des traitements. On s'emploie constamment à remettre à jour les publications de la série qui ont perdu de leur actualité.

La présente brochure est un texte revisé des monographies relatives au génie contenues dans *Carrières dans les sciences naturelles et le génie* et elle a été préparée pour la Division des ressources en effectifs de main-d'oeuvre par M. Joseph P. Caccamo et M. William Allison, chef de la Section de l'analyse des occupations. Les auteurs sont reconnaissants de l'aide et de la collaboration que leur ont accordées le Conseil canadien des ingénieurs professionnels, l'*Engineering Institute of Canada* et d'autres organismes qui s'intéressent au génie.

Le directeur de l'économique et des recherches,
Ministère du Travail,
J. P. FRANCIS.

Janvier 1964

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Occupations au Canada
Monographie 20

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Direction de l'économique et des recherches
du
ministère du Travail, Canada

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FILMS FIXES SUR LES OCCUPATIONS AU CANADA

Jusqu'ici, le ministère du Travail, en collaboration avec l'Office national du film, a produit les films fixes ci-dessous sur les occupations. Un manuel a été préparé pour accompagner chaque film. On peut les acheter en s'adressant à l'Office national du film, C.P. 6100, Montréal, ou à ses bureaux régionaux. Prix au Canada: copies en noir et blanc, $2; en couleur, $4.

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CANADIAN OCCUPATIONS MONOGRAPH 20

Canadian Occupations
Monograph 20

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IN
PROFESSIONAL ENGINEERING

Prepared by
Occupational Analysis Section
OCCUPATIONAL RESEARCH DIVISION
DEPARTMENT OF MANPOWER AND IMMIGRATION

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FOREWORD

During recent years there has been a steadily increasing demand for information on Canadian occupations. The demand comes from young people faced with the need to choose an occupation and prepare for it; from parents, teachers and vocational guidance counsellors; from workers wishing to change their occupations; from employment service officers; from personnel directors and union officials; from prospective immigrants to Canada, and from other quarters.

The CANADIAN OCCUPATIONS series of monographs is designed to help meet this demand. Each booklet describes, among other things, the nature of the occupation or group of occupations, entrance and training requirements, working conditions and employment prospects.

Occupational information tends to become dated as a result of changes in economic conditions, in industrial technology and in wage and salary structure. This booklet is a revision of Canadian Occupations Monograph No. 20 entitled Careers in Engineering, and was prepared by the National Joint Engineering Society Committee on Student Counselling in conjunction with the Occupational Research Division (Chief, J. E. Andoff). The help and cooperation of members of the following professional associations is gratefully acknowledged:

The Engineering Institute of Canada (*E.I.C.*)
The Canadian Council of Professional Engineers (*C.C.P.E.*)
The Canadian Society for Chemical Engineering (*C.S.Ch E.*)
The Canadian Institute of Mining and Metallurgy (*C.I.M.M.*)
The Canadian Society of Agricultural Engineering (*C.S.A.E.*)
The Canadian Aeronautic and Space Institute (*C.A.S.I.*)
The Canadian Pulp and Paper Association-
Technical Section (*C.P.P.A.*)

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CAREERS IN PROFESSIONAL ENGINEERING

Professional engineers are applied scientists who make practical use of the knowledge made available by science. Employing methods developed by practitioners of the art of engineering over the centuries, they utilize the materials and forces of nature and help organize the human effort necessary to produce the goods and services that satisfy human needs and wants. They are senior partners—often the leaders—in a team of workers that deals with the technical problems presented by any project making use of physical science.

CAREERS IN PROFESSIONAL ENGINEERING

HISTORY AND IMPORTANCE

Man is by nature a builder and an explorer, engineering and creating for himself a more agreeable world out of the materials at hand. Canals, roads, fortifications and other structures, many of them thousands of years old, are evidence of his engineering competence. For hundreds of years engineering was a craft which developed gradually by trial and error; unfortunately, in the Dark Ages much was forgotten. Centuries passed before the technical competence required to construct the irrigation system of the Euphrates Valley or the great pyramids of Egypt was relearned and reapplied. Only as the basic laws of the universe were disclosed was it realized that all engineering principles stemmed from scientific laws, and that the function of engineers was to understand and apply these laws in the design of their works.

Engineering in Canada

Canada is a young country presenting many challenges to the engineer. While many of her problems have been, and still are, those associated with growth and development, others, such as environmental pollution stemming from industrial wastes and urbanization, are demanding attention. The very land which offered resources in abundance also imposed penalties of distance, ruggedness, bitter winters, and isolation from markets. Where land was misused we are left legacies of marginal farmland, soil erosion and water losses.

From the beginning engineers have contributed and continue to contribute to the economic and technological development, welfare and defence of Canada. They design and develop complex systems vital to urban living, such as water treatment, sewage disposal and electric generating plants. They render life more comfortable by developing more efficient heating, air-conditioning and refrigerating equipment. The low price of mass-produced goods is made possible through the engineer's search for better production processes. The mobility of the individual and the transportation of goods depends upon the development, by en-

gineers, of automobiles, trains, ships and aeroplanes together with transcontinental transportation systems and inland water ways penetrating deep into the heart of the country. The activities of engineers in the field of mining have contributed significantly to Canada's world leadership in mineral exports. Scientific research too depends on the equipment which the engineer designs to explore the depths of the ocean and probe the secrets of outer space. Many engineers working for government, a university or private industry have made contributions to our social and economic well-being through the formulation of manufacturing standards and construction codes affecting the safety of workers, the public and the consumer. Other engineers have been instrumental in the enactment of legislation affecting our natural resources, our means of communication and transportation, and our environment. Until the second half of the 19th century there were no courses in engineering offered in Canada, and those engineers engaged in the early development of the country received their education in British, American or European institutions of learning. The first engineering course in Canada was offered in 1854 by King's College, now the University of New Brunswick. Before the end of the century, courses in engineering were provided by McGill University, *L'Ecole Polytechnique* (affiliated with the University of Montreal) and the University of Toronto. Today, degree courses in engineering can be taken at most major universities, and the first two years of study are given in a number of post-secondary institutions of learning. The first Canadian association of practising engineers was instituted in 1887 as The Canadian Society of Civil Engineers. In 1918 it was renamed The Engineering Institute of Canada and broadened in scope to include all the fields of engineering. Under the terms of the British North America Act, regulation of the professions is a provincial responsibility. Each province has legislation governing the practice of engineering and has vested certification or licensing authority in the provincial engineering association. The activities of these associations are co-ordinated by the Canadian Council of Professional Engineers which was formed in 1936 to represent them, in non-technical matters, at the national level. It is estimated that there are nearly 64,000 professional engineers practising in Canada. Statistics show that in 1970 engineers were distributed throughout the various fields as follows:

civil engineering	16,300
mechanical engineering	13,800
electrical engineering	13,500
chemical & petroleum engineering	8,700
mining engineering	4,200
other fields	7,400+

For centuries engineering tended to be a man's profession, but in recent years more and more women are being attracted to it.

NATURE OF THE WORK

Broadly speaking, engineers are applied scientists who work with the forces and resources of nature to create new products and processes to satisfy human needs and wants. While pure scientists strive to enlarge mankind's consciousness of the universe and understanding of the laws of cause and effect, engineers are primarily responsible for putting the resources of science to work. They are, for instance, more interested in generating electricity than in enquiring into its nature; more interested in using things than in studying the state of things. Engineers must pay close attention to the human, economic and financial aspects of a project.

Engineers, whether practising in a narrow specialty or working in a broader field, usually find themselves engaged in one or more of several functions, such as design engineering and systems engineering described in later paragraphs. Eventually, they tend to concentrate on that which they feel best fitted to perform. Within each field there is a choice of work functions, some of which are more characteristic of a particular field of engineering than others. For example, a fairly high percentage of civil engineers are employed in construction, which needs only smaller groups of engineers from other fields. The following chart shows how these functions are distributed among the various engineering fields.

ENGINEERING FUNCTIONS

ENGINEERING FIELDS	Research & Development	Design Engineering	Systems Engineering	Production and Process Engineering	Industrial & Maintenance Engineering	Construction, Installation & Erection	Field Exploration	Consulting Engineering	Sales & Service	Teaching
Civil	√	√	√	√	√	√	√	√	√	√
Chemical	√	√	√	√	√			√	√	√
Electrical	√	√	√		√			√	√	√
Mechanical	√	√	√	√	√	√		√	√	√
Geological	√						√	√		√
Mining	√	√	√	√	√	√	√	√		√
Metallurgical	√	√	√	√	√			√	√	√
Petroleum	√						√	√		√
Physics	√							√		√
Aerospace	√	√	√	√	√	√		√	√	√
Biomedical	√		√					√		√
Agricultural	√	√		√			√	√		√

RESEARCH AND DEVELOPMENT

Research is conducted by engineers in co-operation with scientists, and entails investigation and evaluation, and the application of engineering and scientific principles to practical problems. Studies are made in such areas as pre-stressed concrete construction, high-pressure instrumentation, continuous processing of chemicals at high and low temperatures and pressures, supersonic flight and electronic-computer and control systems. Research activities are exploratory and experimental in nature and involve a considerable use of trial and error. This is particularly true of fundamental research, the first level of research activity, usually associated with revealing and understanding the laws of nature or in

discovering new principles and techniques. Mission-oriented research, the second level of research activity, by necessity is creative and devoted to converting new ideas and principles to commercial realization or to improving existing processes or techniques. Fundamental research is carried out largely in universities and government agencies, while, to an increasing extent, mission-oriented studies are the preserve of industry-sponsored research institutes and of industry itself; always with the creative mind of the inventor behind it as the driving force to succeed.

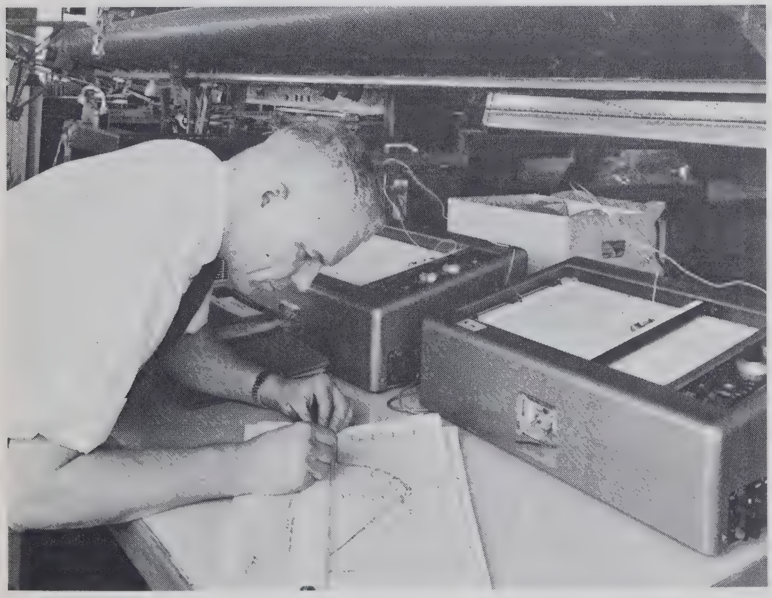
A research engineer determines magnetic susceptibility of a mineral by using a microbalance and an electromagnet. C.I.M.M. 14945

Engineers concerned with research and development need to be abreast of all trends in areas related to their field. The necessary attributes include a capability for creative thinking, analytical and logical reasoning, and a capacity for intuitive and original problem solving. Other essential characteristics demanded of the researcher are a curiosity to experiment, the ability to learn from failures and the persistence to continue despite such failures.

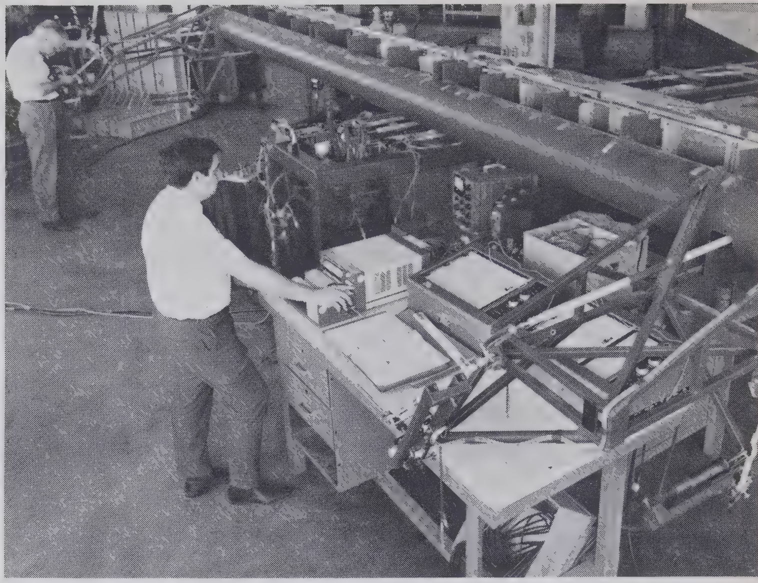
The activities involved in this type of work include the development and testing of new technologies, new products and prototypes of new installations; utilization of new methods and techniques of analysis, production or construction; the use of new materials, or the resolving of special problems.

DESIGN ENGINEERING

Whether concerned with one component of a new piece of equipment, or an entire system, design engineering consists of applying established scientific or engineering principles to meet



Design engineer assesses test results from an aircraft control system test rig. CANADAIR 8947



Design engineer and technician test wear, load endurance and limit load of aircraft control system. CANADAIR 8946

functional requirements and performance specifications, and to developing prototypes, structures or processes. Involved here are technical problems of size, strength, weight, shape, durability and efficiency that must be solved with regard to costs and human needs; they may also be complicated by aesthetic considerations.

The human element poses fascinating problems to design engineers, for they must consider the need for safety, comfort and convenience when designing the product.

Design engineers must be aware of developments in the various fields of research and must consult frequently with colleagues and those responsible for translating the design into a saleable product.

SYSTEMS ENGINEERING

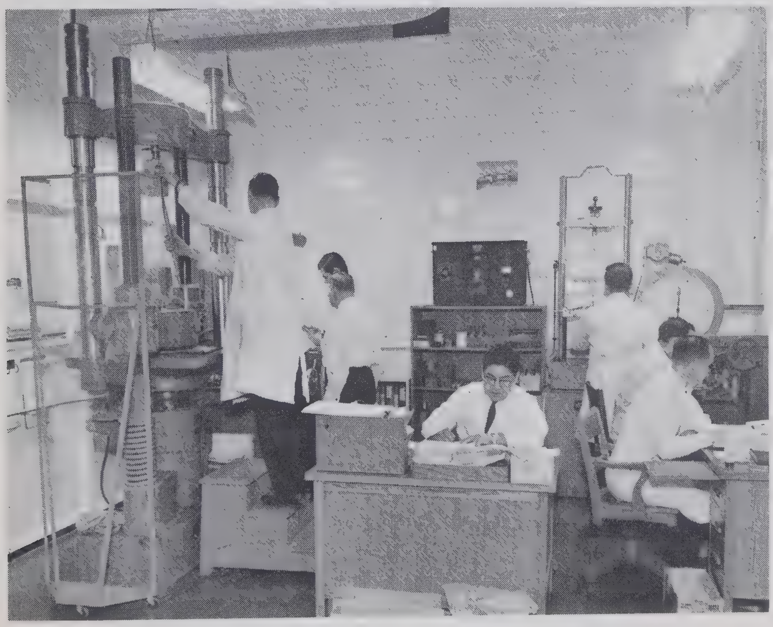
Systems engineering is the treatment of a complex project as a single concept instead of as a number of individual parts. The design and development of such a project must take into consideration all its aspects to ensure that the system will fulfil its intended purpose.

A typical illustration of systems engineering is in the design and construction of an airport. Although its purpose is to permit planes to land and take off, it is not sufficient just to design and construct buildings and runways. The final design must also consider transportation to and from the airport, and efficient flow pattern within the airport so that people can move quickly and comfortably, baggage can be loaded and unloaded with a minimum of delay, and food and supplies can be moved rapidly.

The smooth functioning of such a complex system poses many problems, and the systems engineer identifies, analyses and solves them using a special knowledge of mathematics and an understanding of the properties and functional characteristics of the components forming the system.

PRODUCTION AND PROCESS ENGINEERING

Production engineering is complementary to the design function, and production engineers are frequently responsible for implementing a new product design or modifying one according to



Materials test laboratory. D.H. 2607

considerations of production techniques, cost or efficiency.

Whether the project is a single item, such as a bridge, or the factory production of many identical items, planning is essential to the logical and efficient arrangement of plant equipment, machine tools, purchase of materials and organization of pro-

Factory liaison engineer discusses test pieces with operator of autoclave used in the bonding of metal parts and the manufacture of honeycomb components. CANADAIR 8942

duction workers, so that the project will move ahead according to a predetermined cost and schedule. Production engineering also entails the supervision of production processes, plant layout, work methods and production scheduling.

Process engineering, on the other hand, involves the control and operation of one or more process lines in a continuous manufacturing operation. Generally process engineers deal with fluid flows as found in such industries as oil refining and chemical and wood-pulp production. They advise at the design stage of operations and, if the process line does not meet design standards of product quality and output, they may suggest changes or improvements.

INDUSTRIAL AND MAINTENANCE ENGINEERING

Industrial engineering is a field which has developed rapidly over the last twenty years. Basically it involves the application of engineering principles to large-scale production, and the devising and initiating of procedures to make it efficient. The techniques of industrial engineering call for the application of mathematics, knowledge of both physical and social sciences, operational research and the use of computer systems. These skills are employed in the installation of integrated systems of equipment, materials and manpower, and the prediction and evaluation of the results obtained from these systems. The principles of efficient operation of factories and plants are equally applicable to department stores and government departments. Industrial engineering involves planning plant lay out, work flow, accident prevention, work-study techniques, training programs, and inventory-and-quality control.

Maintenance engineering is primarily concerned with keeping machinery and equipment in a production or service operation in good order. Maintenance engineers are responsible for establishing regular maintenance schedules which include inspection, cleaning, parts replacement and general overhaul. In many cases they may serve as maintenance superintendents and supervise the work of technologists, technicians and tradesmen.

CONSTRUCTION, INSTALLATION AND ERECTION

Construction engineers plan and design such structures as buildings and bridges, and supervise their construction. They apply their knowledge of materials and their properties to produce practical and stable structures. They direct and oversee the workmanship, equipment and materials that go into the project, maintain the proper sequence of operations and ensure that work is done according to design and on schedule.

FIELD EXPLORATION

Field exploration in Canada is chiefly identified with seeking out and proving oil and mineral resources, but also includes soil testing at the site where large structures are to be erected; hydrographic survey for water power, irrigation or flood control; and other explorations of engineering importance. This work usually entails travel, often in winter, to distant and uninhabited regions, by whatever means of transport are available. Use of electromagnetic and seismic instruments, diamond drilling bits and examination of core samples is customary in this type of work. The often harsh climate and terrain in Canada have led engineers to develop some ingenious techniques for prospecting from the air. Variations on some of these methods will likely be used for initial exploration of the moon and planets.

SUMMARY

The functions as outlined are those associated with the purely technical aspect of engineering: in practice they are rarely so neatly compartmentalized. The majority of active engineers will likely be found in one field or a combination of several. There are also a number of other functions, such as the following, which are closely related to or dependent on engineering principles.

Consulting Engineering

Consulting engineering differs from other engineering functions, for it requires, in addition to technical knowledge and professional experience, competence in business principles and a good grounding in the laws and regulations prevailing in the area of practice.

Engineers, in business for themselves, in partnership with other engineers, or as employees of larger firms, render a variety of professional engineering services to clients on a fee basis. This fee may apply to a specific project or be for services provided over an extended period. Such services could include the design of structures and roads, providing advice on the efficient and proper application of engineering systems to production processes or, after a limited amount of research and analysis, the furnishing of details with respect to the development of new products, materials and systems, or the solutions to specific engineering problems.

The work of consulting engineers can be divided into five activities:

(1) Advisory services for a particular project or problem, or on a continuing basis. Such services may call for advice on management, production, inspection, testing and quality control. Other services may include appearance before judicial and regulatory bodies to give evidence or submit opinions based on engineering knowledge.

(2) Preliminary and feasibility studies to determine general layout and design, and to estimate cost and time required to complete a project.

(3) Preparation of designs, specifications and contract documents; analysis of tenders and recommendations relating to them.

(4) Contract administration and project management.

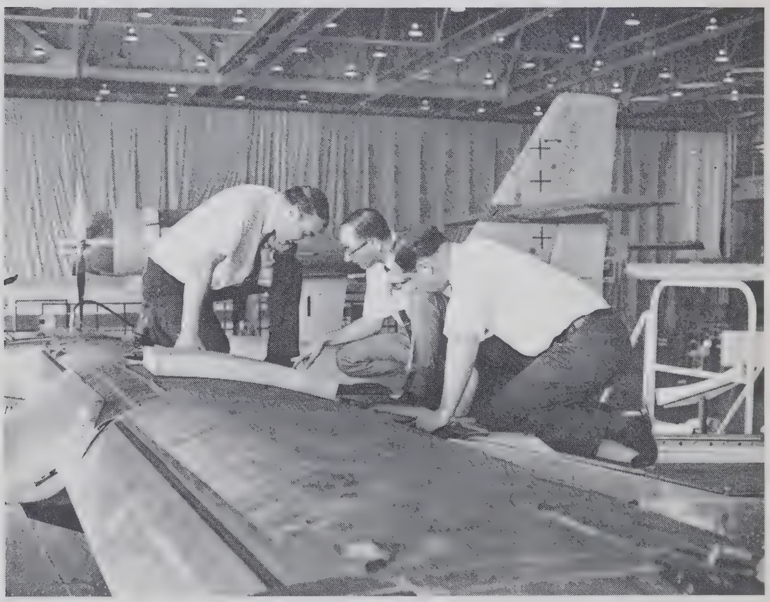
(5) Design and development services, often performed in conjuction with the client's own staff, may consist of processes, special machinery, or the application of automatic controls for equipment. Advice and assistance is sometimes given in developing inventions and registering patents.

Consulting provides opportunities for engineers, so inclined, to work on their own account rather than as employees. It gives them a measure of independence not enjoyed by employee engineers; it also demands high technical competence, some financial risk and exceptional personal qualities. Consulting offers a wider scope for technical practice and the demand for such services appears to be growing.

Sales and Service Engineering

Sales and Service engineers combine a knowledge of engineering with sales psychology to sell products and ideas to industrial or commercial interests. They contact prospective buyers in business, industry and government and present their product or idea. The clients, needs are analysed and recommendations for a beneficial course of action are made. These engineers often provide technical assistance to customers in anticipation that they will purchase the firm's products or services.

New and complex designs have opened up a broad field to the engineer with a sales personality. The work is demanding as it calls for the analysis of field problems and the correct choice of product to meet the needs of the customer. Sales and service engineers must often integrate their product with other devices to ensure efficient operation. Generally, sales and service engineers are expected to travel and to attend seminars, courses and conferences in order to keep abreast of their field.



Sales service engineer and aerospace engineers check control mechanism on CL-84 vertical take-off tilt-wing aircraft. CANADAIR 8938

Dr. Y. N. Yu conducts a demonstration of hysteresis in a transformer. U.B.C. 6

Teaching

Teaching of engineering and related subjects is conducted at the post-secondary school and university levels. Generally members of university engineering faculties possess at least a master's degree and often a doctorate in their field, as well as having a highly developed specialization. In addition, they must have a wide familiarity with engineering principles and the desire to teach. Beyond the obvious responsibility of imparting knowledge to students, they are expected to conduct research programs and to supervise graduate students in their work towards a higher degree.

Engineers may teach at colleges or institutes of technology, and many, after supplementary training, teach mathematics, chemistry, and physics in high schools.

Management (Administration and Executive Posts)

Practically all professional engineers must delegate some authority to assistants; it follows then that they must supervise these people to some degree.

As business and industry become more concerned with modern technology and scientific management, the rational and precise nature of engineering training is of increasing value in administrative and executive positions. For this reason, there are many top- and middle- management posts in industry that are occupied by engineers, who although they do not use their technical knowledge in everyday duties, frequently find that critical decisions required of them call for technical as well as business judgements.

As an example, the purchasing function in manufacturing and fabricating industries is frequently exercised by persons with an engineering background. There may be several engineers of diverse technical backgrounds in a large purchasing operation, with one heading the department or division as manager or vice-president.

Advancement to these positions usually leads to duties with less and less technical content as the administrative function becomes increasingly important, and many qualified engineers performing this function undoubtedly consider themselves primarily executives rather than engineers.

THE MAJOR FIELDS OF ENGINEERING

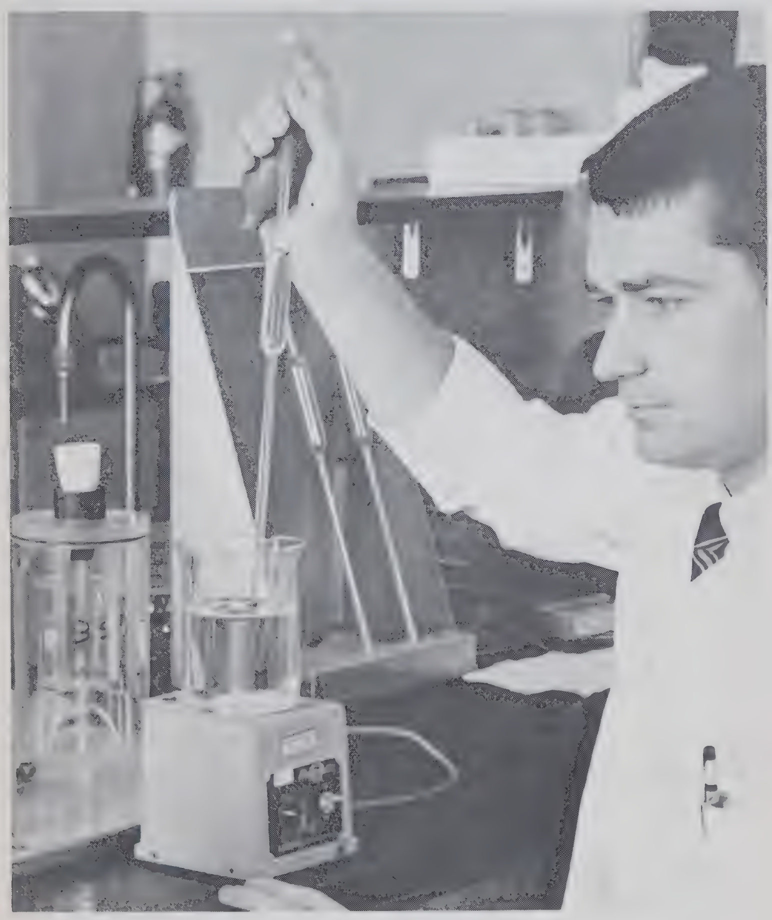
The early development of engineering took place centuries ago and was concerned with building fortifications, roads and canals for military purposes. Gradually practitioners in the field became recognized as military engineers, and builders engaged in the design and construction of civilian works were known as "civil" engineers. Thus the early field of "civil" engineering included all works of a non-military nature.

As scientific knowledge expanded during the 19th century, some civil engineers began to work in the emerging fields of mechanical, chemical and electrical engineering, and these specialties gradually became recognized as separate branches of "civil" engineering. By the turn of the century this trend had become well established and the term "civil engineer" was applied only to those engaged

in the design and construction of buildings, bridges, highways and railway rights-of-way, as examples.

CIVIL ENGINEERING

Civil engineers design and supervise the construction of roads, harbours, airfields, bridges, tunnels, buildings, water supply and sewage systems. Many specialize in one phase of civil engineering, such as, hydraulic-, sanitary-, or highway-engineering. Others



Water resources engineer takes measurements on tower feed and affluent. C.S.Ch.E.

occupy administrative positions ranging from supervisor of construction projects to executive. They are often involved in large-scale projects where the natural environment presents great challenges to their professional skills. Because of this, one of the prerequisites of the design and construction of many civil engineering works is a thorough knowledge of the surrounding terrain. Such information may be obtained from existing maps or it may be necessary to conduct surveys; these may be restricted to topographical detail or include information about the sub-soil, rock structures and water flow.

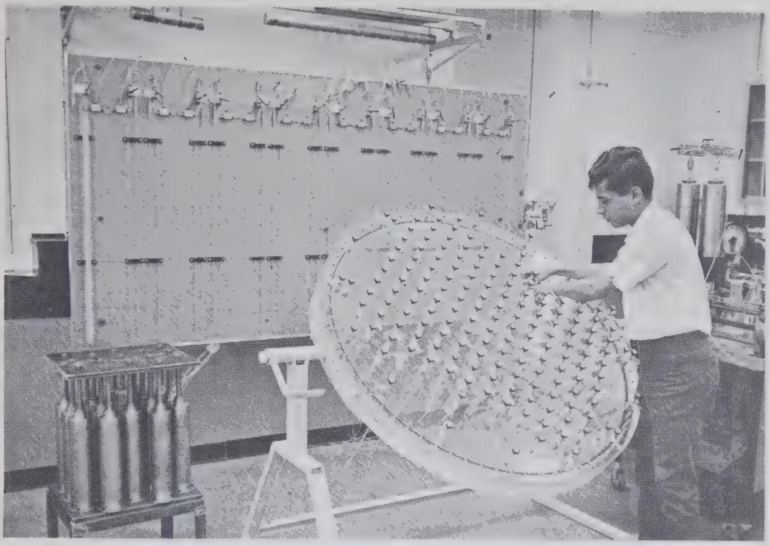
Many famous civil engineering works relate to the use of liquids; typical of these are the Churchill Falls hydro-electric development in Labrador, the St. Lawrence Seaway, and the Canada-wide pipeline systems for oil or slurries. These projects all required large numbers of civil engineers with a basic understanding of hydraulics, hydrodynamics, and hydrology, as well as others with special skills in soil mechanics, foundations, structural design and heavy construction.

While mass concrete and steel superstructures are normal in large developments, new techniques using pre-stressed concrete or very high tensile structural steels, and other newly-developed materials and systems have opened up new vistas for the structural designer. These have made possible large dome-shaped structures and pre-stressed concrete bridges.

Other fields of interest to the civil engineer are found in urban planning and regional development. Here a wide variety of skills are used to provide transit systems, airports, water supplies and freight transportation as well as environmental controls to maintain an acceptable standard of air and water purity and noise levels.

CHEMICAL ENGINEERING

Chemical engineers are mainly concerned with systems in which matter undergoes some conversion in the manufacturing of a product. As distinct from chemists, whose interests are in the fundamentals of chemical reactions, chemical engineers are engaged in the design and operation of industrial plants, and in supervising the research and development whereby processes and products are improved and new ones are conceived. For example, the production of nylon; food products (instant coffee); the re-

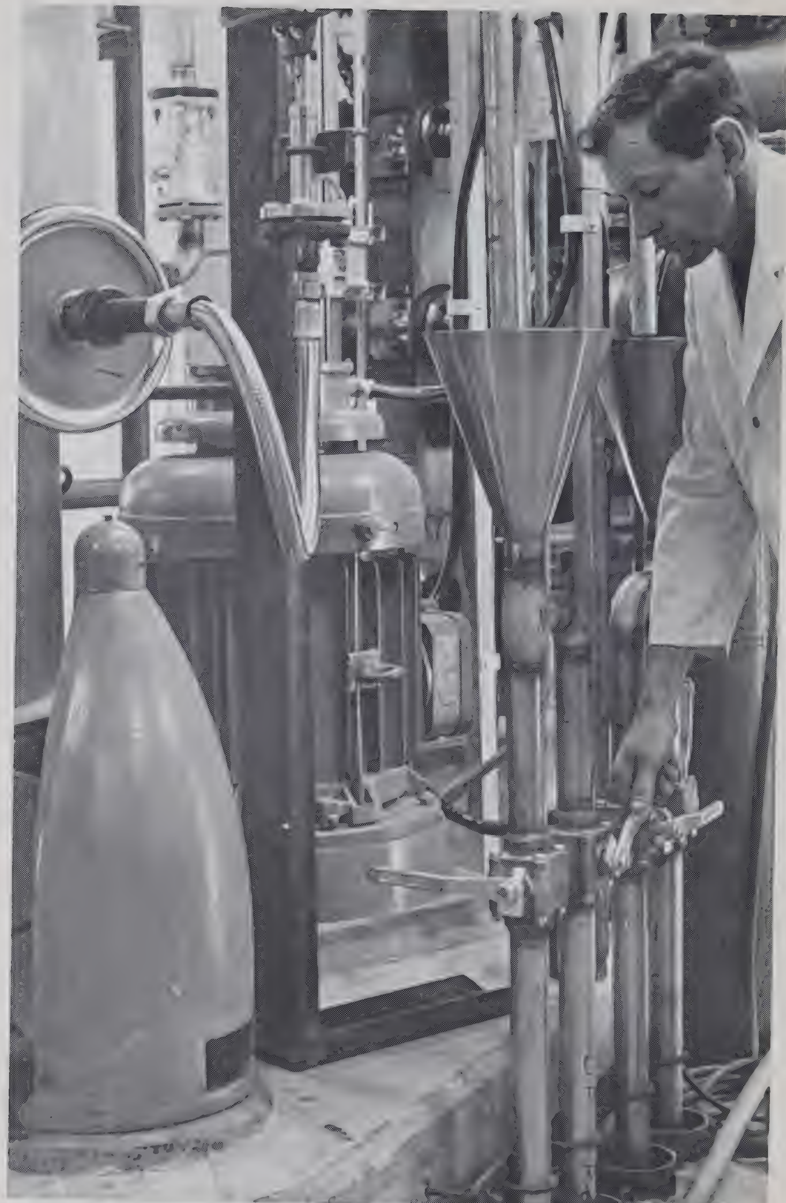


Chemical engineer conducts kinetic and catalytic studies of sulphur recovery by Claus process. C.S.Ch.E.

covery of chemicals from noxious wastes; and the conversion of crude oil into fuels, lubricants and petrochemicals.

The chemical engineering approach is to reduce these diverse processes to a series of basic operations such as distillation, filtration and mixing, each of which is fundamentally the same in all process industries.

Chemical engineers are vitally concerned with change: new products and processes are developed in the laboratory and ways must be found to adapt them to operations on an industrial scale. Starting from the laboratory stage, where precision instruments are used and the unit of measurement is often the gram, the engineer must bridge the gap to the commercial production process, in which tons of material are moved by conveyors or pipelines and processed in large vessels equipped with automatic controls. To cope better with continuous processing, there is a marked increase in the use of computer controls both in the research laboratory and on the production line. In fact the study of computer science has become an integral part of the chemical engineering program at all universities. Chemical engineers have contributed much to the development of this technology.



Chemical process engineer in fine chemical plant of Canada Packers Ltd. C.S.Ch.E.

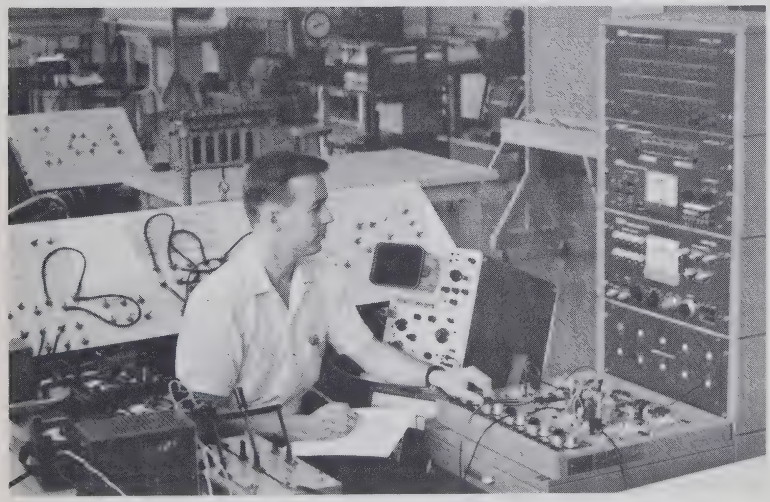
The diversity of chemical products allows the engineer a wide choice of many fascinating fields. For example, polymer engineering which deals with the forming and processing of long molecules in the manufacture of synthetic rubber and plastics; the manufacture of synthetic fibres such as nylon, acrylic and polyester, which are used in textiles; and the production of epoxy resins which, used with fibreglass permit vastly improved strength-to-weight ratios.

In the reverse process of polymerization, we find chemical engineers in petroleum refineries, breaking down molecules of crude oil into smaller molecules to yield fuels, lubricants, and a large variety of by-products such as butane.

Other interesting fields are in pulp and paper, the processing of mineral ores, air- and water-pollution control, pharmaceuticals and protective coatings. Along with other specialists, chemical engineers, work in such fields as space technology and biomedical engineering.

ELECTRICAL ENGINEERING

Electrical engineers are concerned with the production and distribution of electrical power and electrical signals. Those en-



Electrical engineer investigates realization of negative resistance, for use in an A.C. power system model. U.B.C. 3

gineers specializing in the power field, design, develop and evaluate heavy machinery, and power transmission and distributing systems used by utilities, as well as electrical appliances and control systems used by industry, commerce and the public. Engineers specializing in the field of electrical signals, design, develop and evaluate television, radio, telephone and other communication systems, computers and data processing equipment and a wide variety of metering devices.

Work is usually conducted in an office equipped with reference books and other sources of data. At times, engineers are required to make field trips to study problems and discuss them at first hand with other specialists or clients.

Electrical engineers often work on projects as members of a team comprising scientists, engineers from other specialties and technologists. For example, civil engineers are involved in the designing of power houses and transmission systems; mechanical engineers in the designing of machinery; chemical engineers in the designing of electromechanical processes; while the designing of radar and navigating equipment calls for specialists in aeronautics, meteorology and astronomy.

MECHANICAL ENGINEERING

Mechanical engineers are concerned with the design, manufacture and operation of machinery that produces, transmits or uses power or heat energy. They design and develop internal combustion engines, steam and gas turbines, jet and rocket engines and nuclear reactors. The types of equipment which are the concern of the mechanical engineer are too numerous to list, but refrigeration and air conditioning installations, elevators, machine tools, printing presses and steel-rolling mills are a few examples.

Mechanical engineers tend to specialize in such fields as machine design, heating, ventilation and air conditioning, refrigeration, automobile components, and electric generating plants—both thermal and hydro.

In general, mechanical engineers prepare designs and cost estimates for machines, mechanisms and industrial processes. They analyse and solve problems by conducting research and correlating data, and supervise the preparation of drawings and specifications. They direct feasibility studies, construction modifications, and the testing of prototypes, products or pilot plants. Evaluation may be

made of installed plants, industrial processes and products to ensure compliance with specifications and procedures.

Despite the emphasis on theory, mechanical engineers are practical people. At university they do much laboratory work and often simulate designs and build models or even prototypes. While primarily concerned with theory in the office they must be prepared to follow their design through the manufacturing process and check its suitability in use.

It is clear that the skills listed above are used in many industries. The traditional mechanical industries are the railway, power plant, automotive, metal, farm implement, heavy equipment and machine tool industries; however, mechanical engineers work in non-mechanically oriented industries, such as pulp and paper, electrical equipment, utilities, computers, oil and chemical processing, rubber and instruments.

GEOLOGICAL ENGINEERING

Geological engineering entails the study of rocks and unconsolidated sediments (sand, gravel and clays) to determine the mineral

Geological engineers with electromagnetic hoops adjust equipment. C.I.M.M. 11968

content and relationship of the surface and subterraneous structure of particular areas. Knowledge gained is used in planning the construction of bridges, dams, highways, railroads and buildings and to aid in exploration and development of mineral deposits. Geological engineers combine an understanding of engineering principles and practices with the science of geology.

The geological engineer may work outdoors or in a research laboratory. He may travel widely or remain fairly static in a mining town, a university or as a member of a government department of mines, or he may work as a consultant with an office based in a major city.

Mining engineer pulverizes ore samples in vibratory mill. C.I.M.M. 55502-2

MINING ENGINEERING

Mining engineers are involved in the planning, organizing and management of the varied and complex operations of mining. Specialized training enables them to cope with the technological problems of the extraction of ore, and in co-operation with metallurgists they study problems of ore processing at the mine. Some mining engineers specialize in rock mechanics, or in mine design and mining methods, and must give serious consideration to proper ventilation, air-conditioning and safety. Others may be involved

Mining engineer checks a core at the Potash Mine, Esterhazy, Sask. N.F.B. 100890

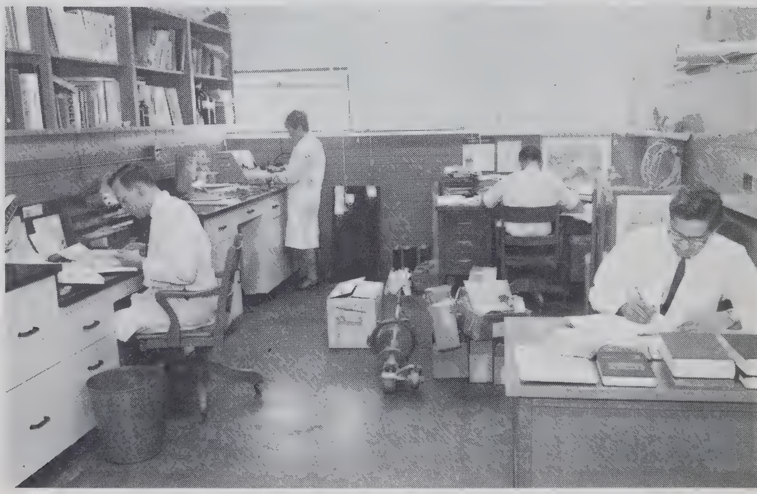
in the economics of mining, and concentrate on systems analysis and control, a field that includes economic analysis, operations research, statistical evaluation and the use of computers.

Mining engineers work on such wide-ranging projects as structural design, marketing, community planning and the extraction and processing of ores. In other situations, they design dam foundations, highway roadbeds, tunnels and underground powerhouses. Most, after several years experience, specialize in a particular field.

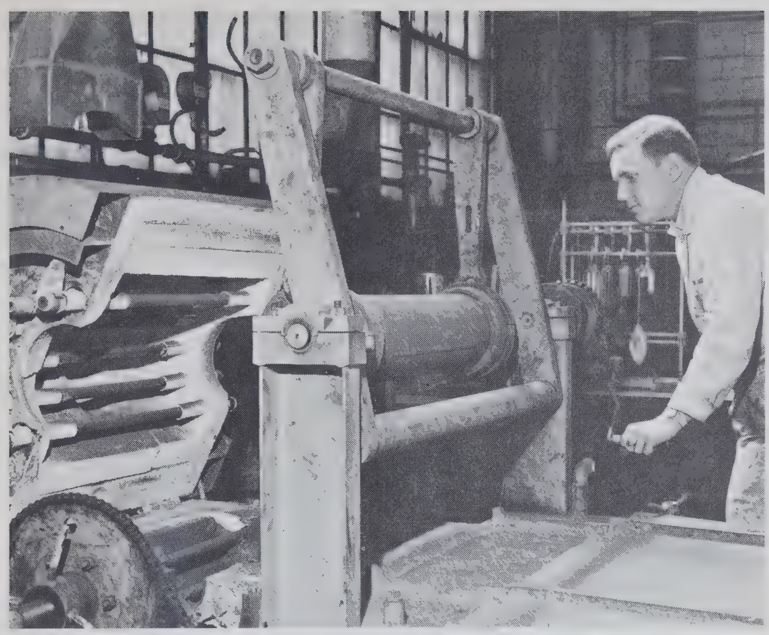
Mining engineers must have a good general knowledge of the physical sciences and of related engineering fields, plus a special knowledge of fields peculiar to mining. They are trained in the principles of geology and general engineering, and must keep abreast of current economic trends and the latest developments in the technology of mining, mineral processing, metallurgy and related sciences. A career in mining engineering offers travel opportunities, varied surroundings, exposure to other cultures and contact with many interesting people.

METALLURGICAL ENGINEERING

Metallurgical engineers develop methods of processing ores and converting metals and minerals into useful products. They generally



Metallurgical engineers in laboratory. D.H. 26066



Metallurgical engineer using a miniature kiln, experiments in the direct reduction of iron ores into usable metallic iron. C.I.M.M. 60196

work in one of three areas—mineral processing metallurgy, extractive metallurgy and physical metallurgy. The first encompasses the treatment of an ore to concentrate the desired minerals (beneficiation) and to produce workable mineral concentrates. The second is concerned with the extraction of metal from ores and the refining of it to obtain pure metals. The third area deals with the properties of metals and alloys and with methods of converting refined metal into useful products.

Mineral processing engineers study ore samples and recommend methods of concentration to provide the highest recovery at the lowest cost. This requires familiarity with mining, smelting and general engineering practices, and an awareness of current technology and market prospects.

Extraction metallurgy engineers deal with the separation of the metal from the mineral in which it occurs, after the processing or beneficiation. This is generally achieved by smelting, leaching or

electrolysis; however, new and improved techniques may have to be developed. Such work requires a knowledge of inorganic and physical chemistry, fluid flow and heat transfer.

Physical metallurgy engineers study the properties of metals and resolve problems encountered in their conversion and use. This may require research in metal physics or it may be in the practical aspects of metal fabrication or cost. They may study corrosion or be employed in developing new alloys, such as are used in the nose cone of an interplanetary rocket. These engineers may be interested in the grain-structure and atomic structure of metals and use high-powered microscopes, X-rays, spectrographs and electron probes.

Metallurgical engineers are in demand throughout Canada. The discipline calls for a firm grasp of such subjects as chemistry, minerology, physics, mathematics and mechanics; post-graduate training is often essential.

PETROLEUM ENGINEERING

Petroleum engineers study the earth's crust in relation to its deposits of oil and gas and their recovery for commercial use. This involves the design and drilling of wells, pipeline design and construction, as well as the refining of crude oil and the removal of impurities from natural gas. The work is inter-disciplinary, involving chemical, civil, mechanical, electrical and geological engineering. Engineers trained in Canada come directly from one of these disciplines, frequently with a year or two of graduate work in petroleum engineering.

The major aspects of the engineer's work are well drilling, design of the casing and production equipment, and control of an operation to achieve the maximum recovery of oil and gas. The latter requires a special knowledge of the behaviour of high-grade hydrocarbon mixtures, of the porosity and permeability of rocks and of the flow of oil, gas and other fluids through porous media. With some wells reaching a depth of three or more miles, it is obviously a major engineering operation.

The commercial exploitation during the last few years of the tar sands of Northern Alberta illustrates the development of a new technology. These surface sands, rich in bitumen, hold vast reserves of recoverable oil; recent research and development work is continuing to improve extraction technology.

The pipelines running from Alberta to the refineries of eastern Canada provide many interesting challenges. Here the use of automation and automatically controlled flow-regulating devices is essential from an economic point of view and the process control computer is much in use.

With the world-wide demand for energy from all sources continually increasing, a large proportion of future needs will be met by oil and gas.

ENGINEERING PHYSICS OR SCIENCE

Engineering physicists or scientists utilize the theory and knowledge developed by physicists and chemists to design machinery and processes; their specialty occupies the middle ground between

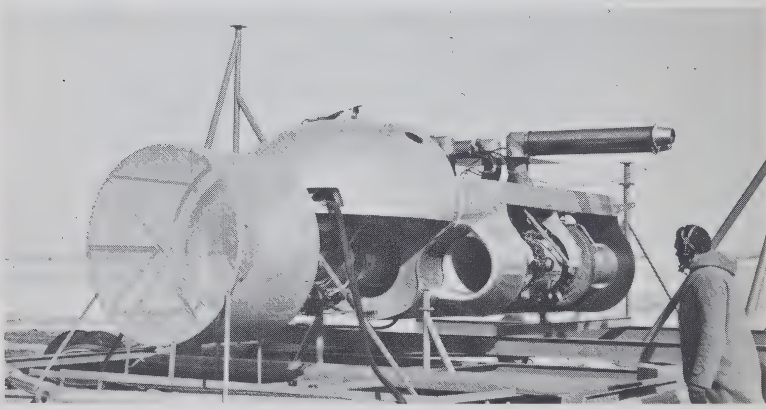
Engineers conduct stress experiments in industrial engineering laboratory, University of Toronto. NFB 63-518/488

the scientist and the engineer. Discoveries in the physical sciences, when translated into practical methods and machinery by the engineer, are used to further advances in other sciences; they are also important for providing new goods and services for the country. An understanding of the properties of light, electricity, magnetism, heat, sound, matter and the nature of chemical reactions are included in the working field of the engineer. It also embraces atomic or nuclear physics, fluid mechanics, optics, acoustics, aeronautics, geophysics and chemical processes.

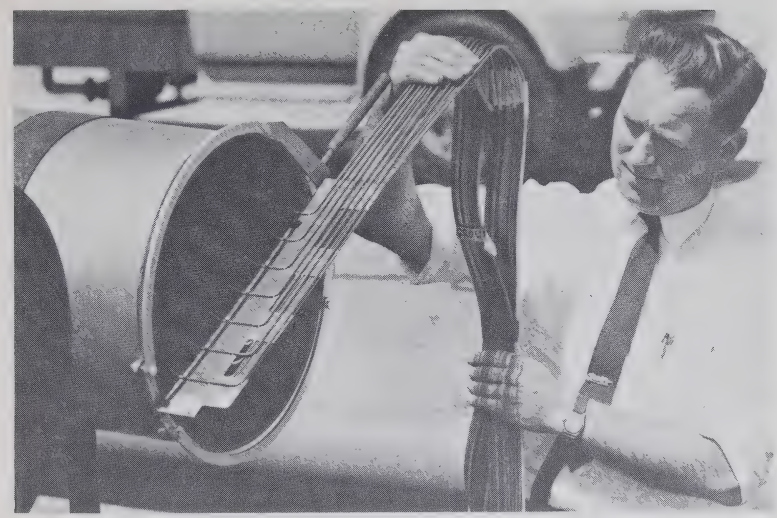
Engineering scientists frequently conduct research for industry, government laboratories and universities. They may conduct tests made in the wind tunnel facilities of a government laboratory, be engaged in the design and application of laser apparatus, or concerned with the development and operation of a radio telescope. They may be employed in a design office in industry, performing mathematical calculations related to aircraft performance or the stability of a structure: or they may work in a university laboratory studying the properties of the ionosphere or the stability of a satellite vehicle.

AEROSPACE ENGINEERING

Aerospace engineers are concerned with the construction and operation of airborne and space vehicles and their associated ground systems.



Aerospace engineer conducts de-inhibiting runs and calibration of Viper delivery flows on model aircraft engine. D.H. 20708



Aerospace engineer measures thrust in DH Augmentor Wing model engine. D.H. 20995

Canada, despite its relatively small population, has made substantial contributions to aerospace technology. Canadian engineers have worked on the design and manufacture of jet engines, rocket motors and aircraft for a wide variety of roles, including craft with vertical and short take-off and landing capabilities. In addition, sophisticated vehicles for operation outside the earth's atmosphere have been designed, built and operated. This is also true of specialized airborne and ground equipment.

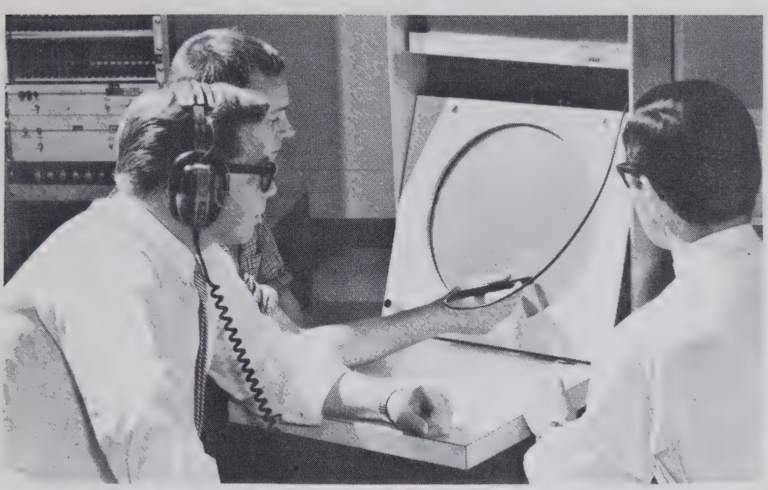
Aeronautical engineers are vital members of the aerospace team. They handle problems related to aerodynamics and hydrodynamics, and often use complex wind tunnels or laboratory equipment in the course of research and development. Owing to the high cost of these facilities, they are normally operated by the federal government or the larger industries. Aeronautical engineers, in addition to contributing knowledge of their specialty, frequently co-ordinate or lead the team.

Modern aerospace technology, as practised in industry, requires the services of specialists whose basic training has been in at least one of the following disciplines: mechanical-, electrical-, civil-, chemical- or metallurgical-engineering, engineering science or mathematics.

Biomedical engineers use engineering knowledge to improve the physical and mental well-being of man. The main function is to bridge the gaps between biology, medicine and engineering so that new knowledge can pass easily and fruitfully between the disciplines.

Biomedical engineering embraces a large number of specialties; the most modern of these are systems and control engineering, bio-instrumentation engineering, applied biophysics, applied biomathematics, environmental engineering and computer bioscience. Practitioners in this field are engaged in all aspects of engineering; from research, through design and development to service and maintenance. Examples of current activity are: computer-controlled biochemical autoanalysers (for blood chemistry, etc.); bio-telemetry; machines which perform the functions of such vital organs as the kidneys, heart and lungs; prosthetics; control system studies of eye movement, posture and locomotion, thermo-regulation, hormonal systems, neural networks; computer-aided processes for pattern recognition of electro-cardiograms and tissue samples used in diagnosis and mass screening.

Biomedical engineer conducts test during research on a reading machine for the blind. U.B.C. 1



Biomedical engineers use computer to synthesize and recognize human speech. U.B.C. 2

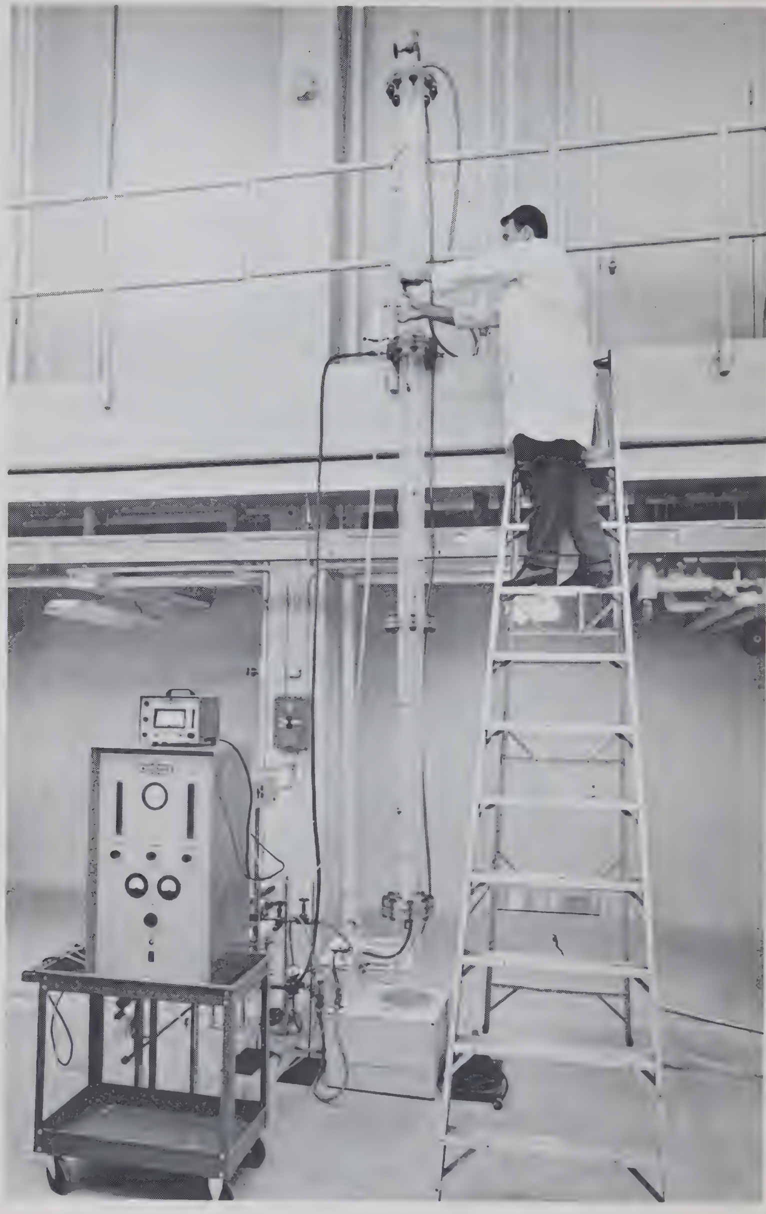
Biomedical engineers are employed in hospitals, industry, government and universities. Newly trained biomedical engineers are now entering research and teaching faculties at universities, or working as members of biomedical engineering departments in hospitals and large industrial firms.

The tremendous advances in medicine and biology currently being made have rendered the biomedical engineer a vital member of the modern health team.

AGRICULTURAL ENGINEERING

Agricultural engineers apply the principles of agricultural science and engineering to develop equipment and methods for improving efficiency in the production, harvesting, processing and distribution of agricultural products.

Work may be associated with power development and machinery design for the production and handling of agricultural and horticultural crops; with the design of structures and systems for the housing and handling of live-stock; with the management, utilization and pollution control of water and the soil; with the utilization of electrical energy and processing in the mechanization of farm systems; or in co-operative research in many areas of



Environmental engineer uses bubble tower to conduct pilot study of sterilization of municipal waste by ozone. C.S.Ch.E.

bio-engineering. Engineers may be employed in a wide variety of private industries which produce machines and equipment and supply services, or which handle agricultural products for the agricultural industry. Some are employed in teaching and research by institutions of learning and government agencies. Others work as engineering consultants.

Degree courses in design, development and other aspects of agricultural engineering are offered by one French-language and six English-language universities.

For students who are interested primarily in sales and service work in the agricultural industry, a BSc in Agriculture with a major in Agricultural Mechanization is generally sufficient.

OTHER SPECIALTIES

The field of engineering is continually expanding to include other specializations; for example, ceramic engineering, textile engineering, weather engineering, marine engineering and environmental engineering.

PERSONAL QUALITIES

A young person considering a career in engineering should have an innate curiosity about the phenomena and laws of nature and a strong desire to find the answers. This is generally shown by a keen interest and ability in mathematics, chemistry and physics.

Engineers apply scientific principles to the solution of practical problems; there may be several alternatives with the final choice being dictated by form, function and cost. Consequently, imaginative, creative and analytic qualities are most desirable in the make-up of a prospective engineer, together with the ability to understand the economics of a problem, and to work consistently and carefully.

The preparation of plans and specifications is a normal engineering responsibility; equally or even more important is the ability to communicate clearly and effectively, orally or in writing, with assistants, employers and colleagues.

Engineers must be able to work well with other people, both in delegating work to subordinates and in working for senior colleagues or for clients. They require qualities of leadership to convince and persuade others and to maintain a professional role.

PREPARATION AND TRAINING

Students are advised to discuss their career plans with their guidance counsellors or teacher during the early years in high school or secondary school; help and advice based upon the student's academic record and aptitudes can thus be provided.

It is customary to enter engineering through a recognized course of studies in university leading to a bachelor degree in either engineering or applied science.

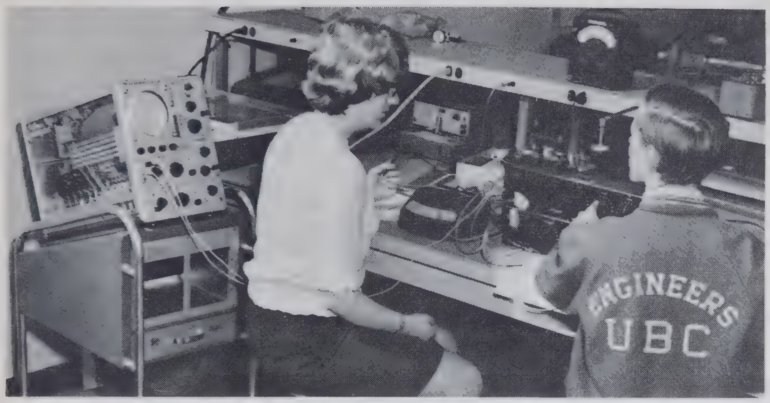
For university acceptance, an applicant usually has graduated from high school or secondary school with recognized standing in such subjects as mathematics, physics, chemistry and English or French. A number of universities also require applicants to take an entrance examination or test.

It should also be noted that university entrance requirements, fees, and course content are continually changing: counsellors should be consulted for information on these changes. Further information may also be obtained by writing to the university or college registrars or to a provincial department of education. In the province of Quebec the first two years of study leading to a bachelor degree in engineering are provided by many of the *Colleges d'Enseignement Général et Professionnel*, popularly known as CEGEP's. These two years are recognized by universities throughout the province and in other parts of Canada, and the student is permitted to register at an advanced level.

University

A bachelor degree program generally requires four years of university study. The first year is the same for all engineering students; in the second and subsequent years, they specialize in a particular branch of engineering such as Civil, Electrical or Mechanical.

Today, the student is exposed to more advanced mathematics, more basic science, and makes much greater use of the laboratory and of scientific method. He is taught to be original and creative in his thinking; to innovate and to cope with the rapid changes of modern technology. Curricula include physics, mechanics, strength of materials, kinetics, gas- and thermo-dynamics, heat transfer, fluid flow, control-systems, and nuclear physics. These broad areas include many courses in mathematics, design theory and the use of



Electrical engineering students at University of British Columbia.
U.B.C. 5

digital and analog computers, and are integrated by the study of analysis and design.

Undergraduates are generally required to satisfy the college or faculty of engineering that they have completed a requisite amount of practical work related to engineering. Requirements range from laboratory or field work at the university to summer vacation employment.

Fees and Living Expenses

The approximate range of annual fees for tuition is from $475 to more than $700, depending on the institution. Living expenses must also be considered, especially if the student lives away from home. Accommodation, including room, board and laundry, may cost from $700 to $1,000 a year. Such items as transportation, text-books and supplies, clothes, entertainment, and other personal expenditures are in addition to this. University calendars usually give information on fees, type of accommodation available and approximate cost.

Part of the cost of attending university can be met by paid employment during summer vacations. There is also a steady increase in financial assistance for deserving students in the form of scholarships, bursaries, grants and loans. Details may be obtained from school principals, vocational guidance counsellors or from university calendars.

Post-Graduate Study

Engineering is a dynamic profession which, in common with the physical sciences, is continually developing. The new graduate has been educated only in the basics of the profession and to be successful must keep informed of major developments in physics, chemistry and mathematics and their application to engineering problems.

A master's degree, and preferably a doctorate are usually required by those intending to follow a career in teaching or research.

After the bachelor's degree, at least one full year is required to obtain a master's degree. At least two full years after the master's degree are required for the doctorate. While a small proportion of engineers are not university graduates, almost all during the past ten years or more have been university trained. There is an increasing emphasis on higher education as a minimum requirement, and an increasing demand for engineers with master's degrees or doctorates. Surveys by the National Research Council reveal that the number of students enrolled in graduate engineering studies at Canadian universities rose to 3,600 (1968-1969) from 1,100 (1962-1963), an increase of over three times in this six year period.

Qualifying By Private Study

It is possible for persons not holding an engineering degree to study privately, pass examinations set by the provincial associations of professional engineers, and in that way qualify as professional engineers (P.Eng.—Eng. in Quebec). This takes many years to do by home study, with little recognition along the way, and only a small number have been successful. For further information, prospective candidates should consult the secretary of the association in their province (see below for list of associations and addresses).

ENTRY INTO THE PROFESSION

The prime requisite for entry into the engineering profession is technical competence gained through adequate education, training and practical experience. Those wishing to use the title "Engineer (Eng.)" in Quebec and the title "Professional Engineer (P.Eng.)"

in other parts of Canada, and legally practise the engineering profession, must be registered with their provincial association of professional engineers.

Registration as a professional engineer requires, as a minimum qualification: (a) a bachelor degree in engineering or equivalent from a recognized university or college, and two years of acceptable engineering experience; (b) the passing of examinations set or approved by the provincial associations in lieu of a degree. An engineering graduate who is in the process of attaining the required experience may use the title "Engineer-in-Training" or, in Quebec, "Junior Engineer". Undergraduates in university, or persons planning to write the examinations set by an association, may be registered with the association as students. Details of entry requirements for each province may be obtained from the following:

—The Canadian Council of Professional Engineers,
Suite 401, 116 Albert St.,
Ottawa 4, Ontario.

—Association of Professional Engineers of Alberta,
604 Royal Trust Building,
Edmonton, Alberta.

—Association of Professional Engineers of British Columbia,
2210 West 12th Avenue,
Vancouver 9, B.C.

—Association of Professional Engineers of Manitoba,
177 Lombard Avenue,
Winnipeg, Manitoba.

—Association of Professional Engineers of New Brunswick,
123 York St.,
Fredericton, N.B.

—Association of Professional Engineers of Newfoundland,
P.O. Box 31,
St. John's, Nfld.

—Association of Professional Engineers of Nova Scotia,
P.O. Box 129,
Halifax, N.S.

—Association of Professional Engineers of Ontario,
236 Avenue Road,
Toronto, Ontario.

—Association of Professional Engineers of Prince Edward Island,
242 North River Road,
Charlottetown, P.E.I.

—Corporation of Engineers of Quebec,
2050 Mansfield St.,
Montreal, Quebec.

—Association of Professional Engineers of Saskatchewan,
2220 Twelfth Avenue,
Regina, Sask.

—Association of Professional Engineers of Yukon Territory,
P.O. Box 812,
Whitehorse, Y.T.

SEEKING EMPLOYMENT

According to recent statistics most engineers work as salaried employees. Consequently, to become established in the profession they usually seek an employer and satisfy him as to their personal qualifications and technical competence. Several sources of assistance are available to engineers and engineering students seeking employment.

Information about job opportunities can be secured from university placement officers, who work in co-operation with the Executive and Professional Division of the Canada Manpower Centres.

In addition, professional and technical associations provide services designed to bring together prospective employers and engineers seeking employment and offer advice to engineers seeking a change of employment.

Daily and weekly newspapers, technical journals and company brochures often list engineering opportunities both in government and private enterprise. Many students make contacts through summer employment thereby obtaining permanent positions upon graduation.

Governments at all levels—municipal, provincial and federal—are large employers of engineers. Competitions for engineering positions with the federal government are posted in public buildings such as post offices, local Canada Manpower Centres and offices of the Public Service Commission.

WORKING CONDITIONS

Professional engineers work under widely varying conditions, depending on their function at a particular time and the field in which they specialize. They may be called from the relative quiet of a research laboratory or design department to the heat or noise of the factory shop; they may leave the comfort of the engineering office and travel great distances to do a feasibility study or to take care of an emergency at a distant engineering project. Engineers are employed throughout Canada, though most live and work in Ontario, Quebec, Alberta or British Columbia. Although engineers are concentrated in large urban centres, they may be required to work in remote and sometimes isolated areas. Many Canadian engineers are also working on projects in foreign countries.

The work day usually conforms to the plant or office hours of their employer; however, an emergency, attention to a difficult technical problem, or the meeting of a production deadline, may necessitate longer hours. Engineers also have a professional responsibility to keep abreast of technical developments in their field by reading, conferring with engineering colleagues, attending seminars and taking courses.

EARNINGS AND ADVANCEMENT

Salary and promotion reflect the individual's responsibilities, performance and qualifications. High technical competence is usually well rewarded; for the experienced engineer the most remunerative positions are in consulting, administration and industrial research. Higher salaries are generally paid for service in remote areas, probably as a form of compensation for the more demanding conditions and isolation.

Newly-graduated engineers are often assigned a variety of jobs to help them get acquainted with the firm's operations. Most large employers have long-term plans for expansion and encourage the ambitious by company-sponsored training courses while on salary, either on their premises or at nearby educational institutions. Trips to technical meetings are arranged and committee and seminar activity is fostered, so that young engineers can learn by contact with experts in their field. Many firms have excellent libraries and laboratories and make time available for research.

Careers in engineering are very varied, depending on circumstances and individual ability, and no single example can be considered representative. Generally, however, the new graduate is assigned routine duties under close supervision in office, plant, field or laboratory. The degree of supervision is gradually relaxed and with experience the young engineer assumes increasing technical responsibility. Demonstrated engineering ability and management qualities may lead to promotion to senior engineering or management levels. Some engineers may establish their own consulting services.

A substantial and increasing number of high-level executives of medium- and large-size industrial concerns have had engineering training. Approximately five percent of all professional engineers in Canada are self-employed as consultants. Annual salaries are directly related to qualifications and the level of responsibility of

the individual, and are among the highest in the professions. Counsellors and placement officers should be consulted for current data on salaries.

A word of caution. An attractive salary should be only one of several considerations when seeking a job. The interest, challenge or opportunities for professional development offered by various types of employment should be carefully investigated in terms of one's personal aspirations and values.

EMPLOYMENT OUTLOOK

Engineering activity varies from year to year, depending on economic conditions, causing short-term fluctuations in the demand for engineers. High school students are advised not to base their career decisions on short-term and often transitory employment conditions. There is a notable coincidence, for example, in the slackening demand for engineers in certain years and a corresponding decrease in engineering faculty enrolments for these years. The decision by a student in the final year of high school to become an engineer may not bear fruit for nearly five years, during which time conditions may change.

Basically, the employment outlook depends on the growth potential of those industries which employ the most engineers, and upon trends in these industries which would make the functions performed by engineers more or less important.

Apart from industrial growth, there is reason to believe that the demand for services which engineers provide will increase even more rapidly. Economic growth is becoming more and more dependent on the practical application of as many as possible of the latest scientific discoveries. The transformation and application of these ideas to industrial and commercial use is, of course, a prime task of the engineer.

The wide range of tasks performed by engineers has already been outlined, and it should be re-emphasized that employers do not hire them only for complex technical jobs, but also for administrative and executive positions. Many firms hire engineers, usually new graduates, because of their suitability for a specific technical job, and because of their potential with the firm. It is expected that they will be able, through training and experience, to make an important contribution in a variety of positions, including, in due course, management itself.

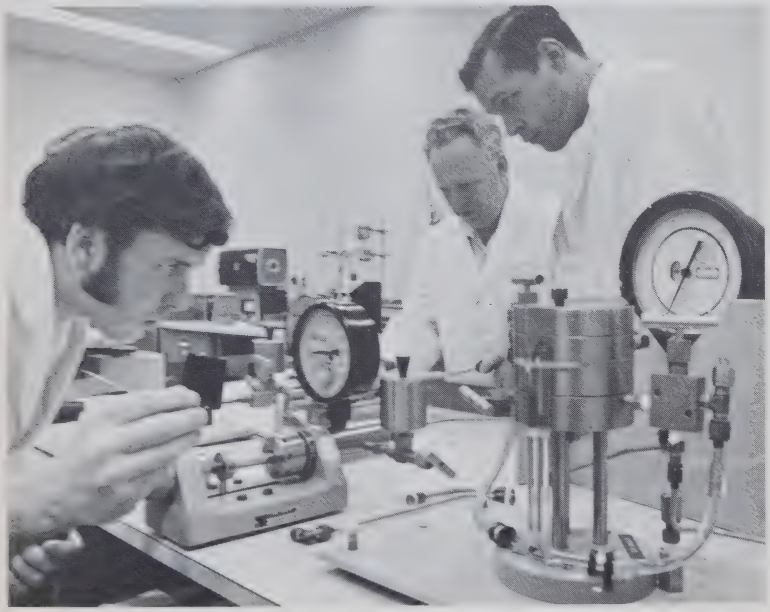
To summarize, employment prospects for engineers in Canada appear very good. Industrial growth and rapidly expanding technology are expected to create job opportunities in this field for many years to come.

RELATED OCCUPATIONS

More and more engineering projects are carried out by teams which are made up of engineers, engineering technologists and engineering technicians. In general, technologists and technicians perform the following duties:

ENGINEERING TECHNOLOGISTS

Assist engineers and other technical workers (or work independently) in the research, design, and development of products, systems, processes and equipment by analysing technical problems, co-ordinating the construction of working models, pilot plants and similar prototypes, and



Engineer directs technicians in calibration of pressure gauges by use of deadweight tester. CANADAIR 8943

by developing and interpreting design specifications for complex equipment and processes, based on engineering requirements.

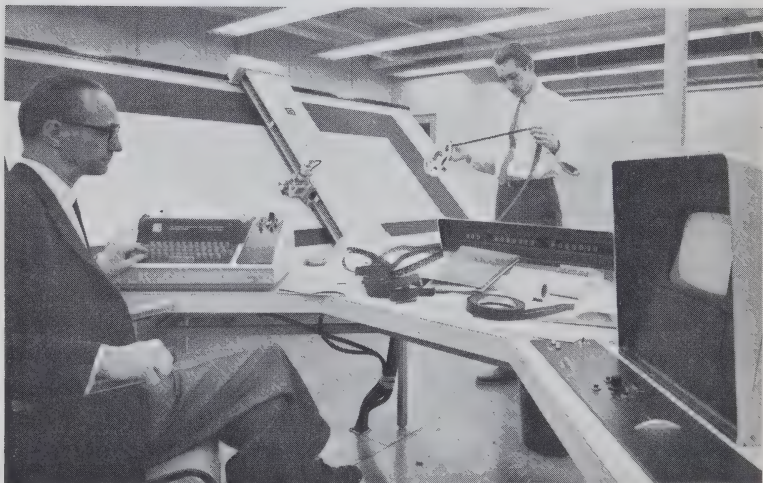
Represent engineers on work or test sites to ensure compliance with design specifications; study objectives and standards relating to production or quality control, and industrial or construction safety.

Examine and evaluate assignments, define problems, determine procedures to arrive at solutions, and schedule work.

Obtain or prepare detailed estimates of time, labour and material quantities and costs for work in such areas as product design testing, construction projects, equipment installations, and manufacturing processes.

Diagnose malfunctions of complex equipment or processes, resolve production or test problems, plan and carry out corrective action or direct other workers in rectifying problems.

Conduct work studies and method analyses, and perform statistical calculations necessary for establishing work standards.



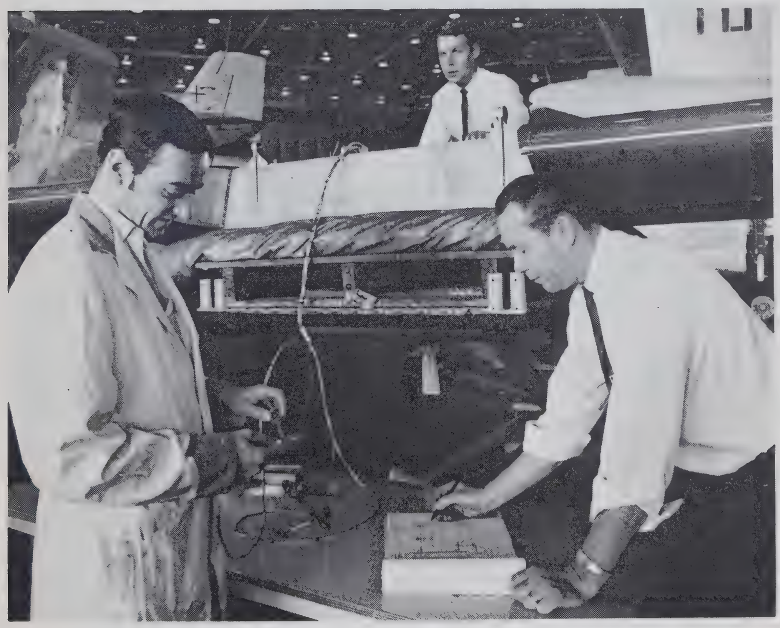
Engineer and technologist operate machine to prepare layouts and to check tapes for numerical-controlled drafting machines in shops. CANADAIR 53225

Interpret and evaluate experimental, test, and other data and prepare reports and recommendations based on evaluations.

Oversee and co-ordinate activities of technicians, skilled craftsmen and other workers engaged in various aspects of technical assignments.

ENGINEERING TECHNICIANS

Interpret work assignment instructions; select and adapt standard procedures, techniques and equipment and establish work sequence.



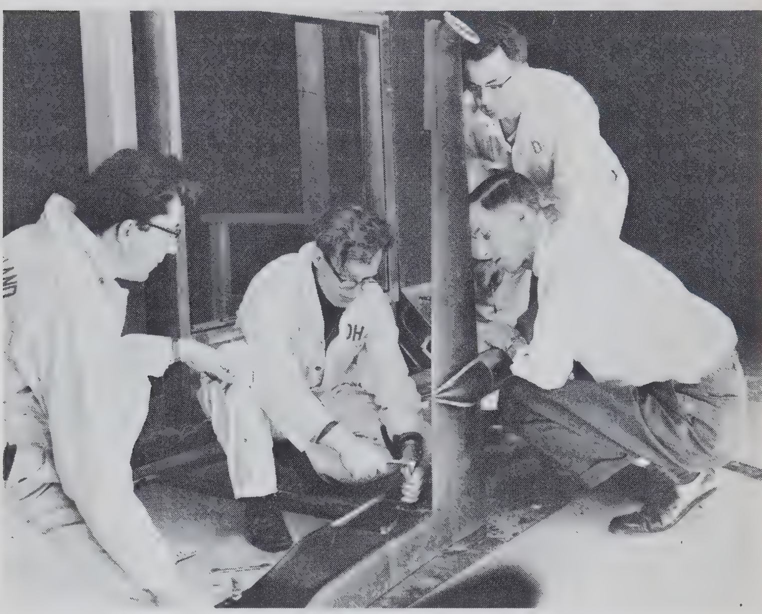
Instrumentation engineers and technician instal accelerometers in tailplane of aircraft. CANADAIR 8937

Prepare, mark, measure or weigh test materials or samples, using various standard techniques and equipment.

Construct, install, maintain, repair, calibrate and modify standard equipment or systems according to standards, tests or instructions.

Adapt and construct auxiliary devices for tests, and operate standard equipment to test materials, samples and products.

Make calculations and prepare charts, graphs and supporting data for reports.



Engineer and technicians instal DHC-5 Buffalo half model assembly in wind tunnel. D.H. 14506

Training in engineering technology is obtained by enrolling in a program at a recognized educational institution. Such programs are offered throughout Canada in more than forty community colleges and allied educational institutions.

Most courses offered by community colleges, although leading to occupational qualification, are not recognized by universities. Some institutions, however, particularly *colleges d'enseignement général et professionnel* (CEGEP's), in addition to diploma courses, offer two years of post-secondary studies which may be counted towards a degree. Persons wishing to advance their careers at a later date should, therefore, consider carefully before selecting a program of studies.

Course length varies from one to three years, and subjects include mathematics, physics, engineering and technical report writing. In most institutions course programs are progressive, and graduates of one-year and two-year courses can upgrade their qualifications by completing the following year. One year-courses prepare students for employment as technicians; graduates of two-year courses qualify as senior technicians; and those successfully completing three-year courses qualify as technologists. Graduates are awarded diplomas or certificates. Tuition fees, including books and supplies, range from $200 to $450 a year.

Financial aid, such as bursaries, scholarships and long-term loans, are available to students with demonstrated ability.

SOURCES OF ADDITIONAL INFORMATION

The organizations of professional engineers welcome inquiries on matters relating to the engineering profession. The Canada Manpower Centre in your area can provide labour market and training information. University calendars, available on request, provide information on academic requirements, course content, financial aid, and tuition and living costs. Specific questions may be directed to the appropriate faculty member.

Practising engineers possess a wealth of first-hand experience which they are usually willing to share with the interested student. Since this source provides a very individual point of view the student should, if at all possible, talk to several engineers of various ages and in several specializations.

Almost any issue of the daily newspapers and financial publications contains some reference to engineering. Technical journals and books on engineering are available in public libraries. The student who is alert to engineering information will notice the abundance of such items. In this way a knowledge of the discipline in Canada and the world may be accumulated.

Biographies of successful professional engineers often provide a clearer understanding of the qualities that make a good engineer and the challenges and rewards that engineering has to offer; perusal of several of these will be rewarding to a prospective student.

Other Organizations With Engineering Membership

—The Engineering Institute of Canada
2050 Mansfield Street,
Montreal, Quebec.

—Canadian Society for Chemical Engineering,
151 Slater Street,
Ottawa 4, Ontario.

—The Canadian Institute of Forestry,
10 Manor Road West,
Toronto 7, Ontario.

—The Canadian Forestry Association,
4795 St. Catherine St. West,
Montreal, Quebec.

—Association of Consulting Engineers of Canada,
176 St. George Street,
Toronto 5, Ontario.

—Canadian Society of Agricultural Engineering,
c/o Ontario Agricultural College,
Guelph, Ontario.

—The Canadian Pulp and Paper Association,
Technical and Woodlands Sections,
Sun Life Building,
Montreal, Quebec.

—The Canadian Aeronautics & Space Institute,
77 Metcalfe Street,
Ottawa 4, Ontario.

FURTHER READING

Books:

Beckhard, Arthur J.—Electrical Genius, Nikola Tesla, New York; Messner, 1969.

Beatty, Charles—Ferdinand de Lesseps—London; Eyre and Spottiswood, 1956.

Forbes, R. J.—Man the Maker—London and New York; Abelard—Schuman, 1958.

Hill, T. L.—The St. Lawrence Seaway—London; Methuen & Co. 1959.

Norway, Neville Shute—Slide Rule—New York; Morrow, 1954.

Parr, J. G.—Man, Metals and Modern Magic—Cleveland; American Society for Metals, 1958.

Rowland, John—Epics of Invention—London; Werner Lurie, 1957.

Sir Casimar Stanislaus Gzowski—A biography, L. Kos-Rabcewicz-Aubkowski and W. E. Greening. Published under the auspices of the E.I.C. Toronto, Burns & MacEachern 1959.

Daylight Through the Mountain—The Life and Letters of Walter and Francis Shanly—Edited by F. Walker, 1957, Published by E.I.C., 1957.

The Engineer—Time-Life Science Library.

McNaughton, Vol. I, 1887-1939 by John Swettenham,—Toronto; Ryerson, 1968; foreword by C. J. Mackenzie.

Brochures and Pamphlets

Your Career in Chemical Engineering—A Vocational Guidance Booklet for High School Students—The Canadian Society for Chemical Engineering, 1967.

Engineering—A Creative Profession—Engineers' Council for Professional Development, New York, 1956.

Opportunities for Graduates in Engineering and Physical Sciences—Public Service Commission of Canada, Ottawa.

Forest Engineers—Department of Manpower and Immigration, Ottawa.

Engineering Careers in Canada—The Engineering Institute of Canada, Montreal.

The Guidance Centre, Ontario College of Education, University of Toronto. Monographs, Engineer—Profession, Chemical Engineer, Metallurgist—Metallurgical Engineer,

The Engineering Profession, Association of Professional Engineers of the Province of Manitoba, Winnipeg, 1959.

A Career For You in The Mineral Industry—Canadian Institute of Mining and Metallurgy.

PICTURE CREDITS

Canadair Limited	CANADAIR
De Havilland Aircraft of Canada Limited	(D.H.)
Canadian Society of Chemical Engineering	(C.S.Ch.E.)
Canadian Institute of Mining and Metallurgy	(C.I.M.M.)
University of British Columbia	(U.B.C.)
National Film Board of Canada	(N.F.B.)

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Canadian Occupations
Monograph 21

CAREERS IN NATURAL SCIENCE

Revised 1961

Prepared
by the
Economics and Research Branch
of the
Department of Labour, Canada

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FOREWORD

During recent years there has been a steadily increasing demand for Canadian occupational information. The demand comes from young people faced with the need of choosing a career and preparing for it; from parents, teachers and vocational guidance counsellors; from workers wishing to change their occupations; from employment service officers; from personnel directors and union officials; from prospective immigrants to Canada and from other quarters.

CANADIAN OCCUPATIONS monographs are designed to help meet this demand. Each booklet describes, among other things, the nature of the occupation or groups of occupations, entrance and training requirements, working conditions and employment outlook.

The series has been prepared with the generous assistance of representatives of management, trade unions and professional associations. The co-operation of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour, and the Dominion Bureau of Statistics is gratefully acknowledged.

Occupational information tends to become dated as a result of changes in economic conditions, in industrial technology and in wage and salary structure. Revision of outdated publications is a regular feature of the series.

This booklet is a revision of the science monographs previously contained in *Careers in Natural Science and Engineering* and was prepared for the Manpower Resources Division by the Occupational Analysis Section under direction of William Allison. The Branch is greatly indebted to the many scientists and scientific organizations whose assistance made this monograph possible.

J. P. FRANCIS,
Director,
Economics and Research Branch,
Department of Labour.

December 1961

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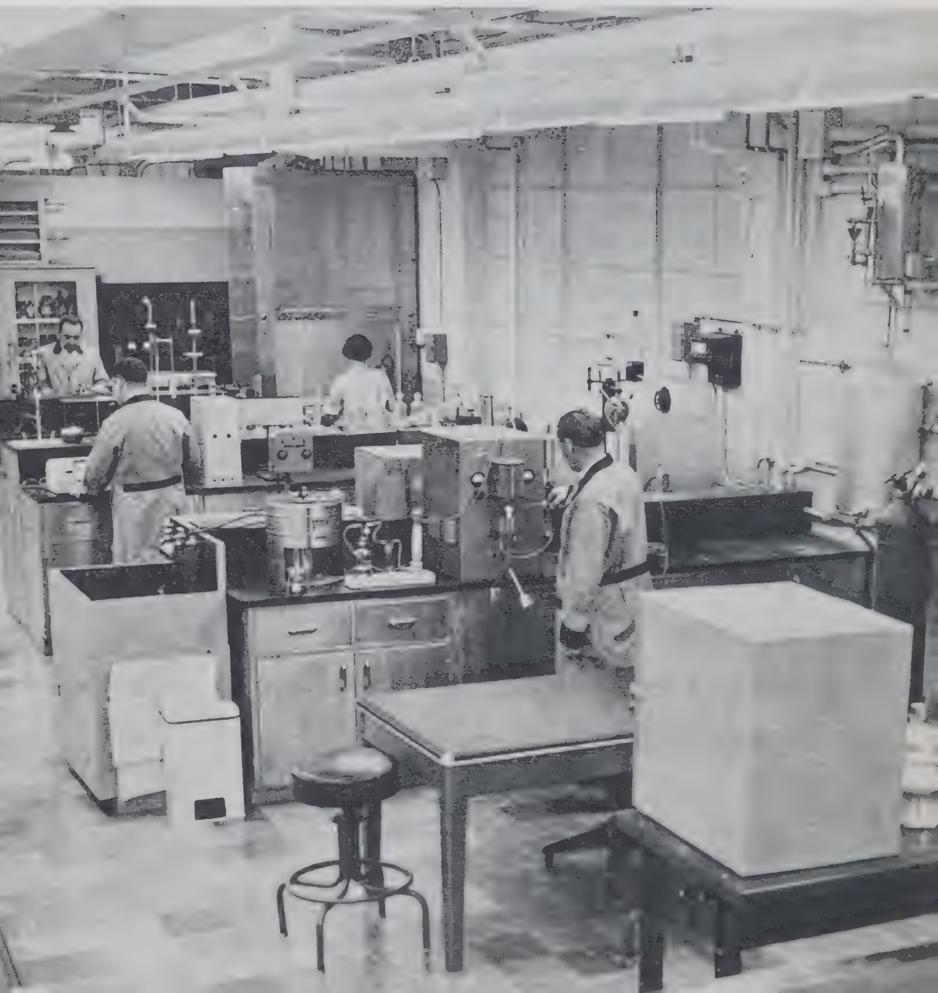
Scientists work quietly in the background to provide new knowledge. Here is a corner of an industrial laboratory.

Photo: Canadian General Electric



CAREERS IN NATURAL SCIENCE

We are living in a society firmly based on technology which, in turn, is firmly based on science. As technology becomes more complex, more and more well-educated scientists will be needed.

DR. E. W. R. STEACIE,
President, National Research Council.

Faced with strengthening competition in world markets, Canada must vigorously expand the development of her natural resources and capacity for production.

We have already gone a long way. Evidence of our development is seen in more efficient utilization of soil, forests, minerals and fisheries, and in the growth of a highly complicated and diversified manufacturing economy. The combination of raw materials, power, working capital, and technical skills, produces an abundance of goods and services for domestic and foreign markets.

Work involved in producing this array of goods and services comprises the broad field of technology, which is the concern of engineers, medical personnel, technicians, craftsmen and mechanics.

Technology is the practical application of scientific principles and discoveries. It can advance only on the heels of advancing science. Scientific research, working quietly in the background to provide new knowledge, is the fountain-head of modern technology. This is the work of the scientists.

The following pages outline broadly what is involved in a career in science and describe the many different kinds of work scientists do. Much can be said that applies to many or all fields of natural science and this is contained in Section I, "Science in General". *Read Section I before passing on to sections dealing with individual science fields in order to get the complete picture.*

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I

SCIENCE IN GENERAL

Science as we know it had its beginning about three or four hundred years ago. Copernicus, da Vinci, Bacon, Newton, Galileo and others of that time were the first modern scientists. What distinguished them from the early speculative philosophers was the adoption of a scientific attitude, out of which developed the *scientific method.* The new scientists replaced myth, superstition and speculation with impartial observation, classification and experimentation to formulate and confirm scientific knowledge.

Many industrial processes, known and used for centuries, are now understood because of science. Through science and engineering, industry has been able to improve and diversify its products even further, so that now scarcely any aspect of modern life is untouched, directly or indirectly, by science. Our food, clothing and living conditions have been changed and improved with the help of science. We are healthier and live longer, are able to travel faster and farther, and have more leisure to enjoy a greater variety of recreation and entertainment than ever before.

Science is often regarded as a coldly factual pursuit, morally neutral. However valid this may be for the scientific method, which aims to be impartial, it tends to overlook the moral impact of the scientific attitude. The scientific attitude, by attacking ignorance and superstition, has made our society more humane than it could otherwise be. Science, by its very objectivity, supports race tolerance, religious freedom, sensible treatment of criminals and the mentally ill. The moral courage of scientists in the defence of truth has been important in the growth of some of our best social practices.

We cannot go back to the "old days". We must learn to live in a scientific age and to use science for the real betterment of mankind. This challenge faces not only the scientist but everyone. The ills of society which are laid at the door of science (the nuclear threat, the cold war power race, mechanized living, highway fatalities, etc.) all result from the uses to which science has been put. They are aspects of our technology, not our science; they reflect the application of science by our society as a whole rather than the will of the scientists.

SCIENCE AS A FIELD OF EMPLOYMENT

As recently as 100 years ago, scientists were not employed in the same manner as they are today, and the majority who were engaged in research were not scientists in their main occupation. Driven by a consuming curiosity about the mysteries of the incredibly complex world around them, they often carried out research on their own time, using their own resources. Some were men of means, or had the help and encouragement of well-to-do patrons; some worked and taught in the stimulating atmosphere of universities, which nurtured the traditions of science from the beginning. Many scientists dedicated their lives to research with no thought of reward other than the satisfaction of their curiosity.

Today, scientific research is a career. Scientists now constitute an important and growing sector of the professional community. While it is still necessary for them to have the same sense of quest and dedication to achieve success and satisfaction, they also find that a career in science offers a challenging and rewarding way to earn a livelihood.

WHAT ARE THE NATURAL SCIENCES?

Science is a systematic body of knowledge, usually formulated during a long period of time. It is a term that may be applied to an entire systematic body of human knowledge, or it may indicate a specific discipline, such as chemistry, psychology, or astronomy.

Natural science is the organized knowledge of biology, chemistry, physics and geology. At the risk of over-simplifying something very complex, the diagram overpage shows how five main fields or branches, often thought of as separate and distinct, are, in fact, quite interdependent.

Study of living organisms (biology) is often involved with the chemistry of living things (biochemistry); study of the earth in terms of physical laws forms the field of geophysics; physics and chemistry meet on ever-widening ground as physical chemistry. Natural science therefore is not a number of separate disciplines, but a complex whole, with many divisions, subdivisions and areas of specialization. Scientists trained in one specialty may find themselves confronted with problems which have been studied in another branch of science.

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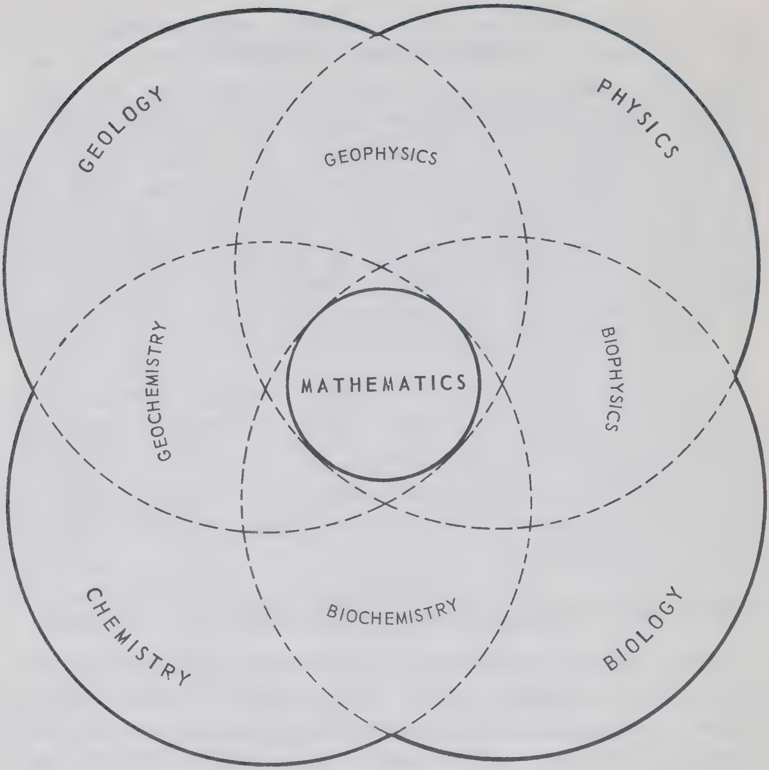

Mathematics is the unifying factor—the abstract language of all science—and also a science in its own right. All scientists must master this important tool.

Many natural scientists are engaged in work relating to agriculture or forestry. Because of the importance of these industries to the Canadian economy, "Science in Agriculture" and "Forest Science" are included as separate sections of this monograph.

NATURE OF THE WORK

Popular notions of the solitary scientist working in a small laboratory on a problem of his own choosing are by no means out of date. However, many scientific problems are now so complicated, and the apparatus and materials for experimentation so

expensive, that the modern scientist is quite likely to be a member of a team of specialists composed of scientists, technicians and, perhaps, engineers or medical doctors, working on a project financed by a university, government department or industrial firm.

Supervision of scientific work is difficult. If scientists are to be creative, they need freedom for independent thought, yet some control must be exercised to keep research within certain defined limits. They also want and need the stimulation that comes from communication and consultation with other scientists. They are on the frontier of human knowledge, and the number of people who speak and understand their "language" is relatively limited.

Because science is primarily concerned with the search for knowledge scientists are, above all, research workers. They may also become involved to a greater or lesser extent in other activities such as industrial production, testing and analysis, directing the work of other scientists and technicians, teaching science, writing about science, or acting as scientific consultants or advisors. Scientists are often astute observers of events, contrary to widespread belief. Today there are notable philosophers and writers who are also scientists.

Modern technology is so all-pervasive that there are also many opportunities for persons with a knowledge of science and laboratory technique to find interesting and challenging work as *laboratory technicians, scientific aides, technical writers, science librarians, science editors,* or *extension workers.* The level of academic achievement needed for this type of work is not as high as that expected of scientists.

WHAT SCIENTISTS DO

Research

Research is the main feature of scientists' work. Ability to do original, advanced research is the factor which distinguishes scientists from most other technical workers.

Research falls into two broad categories, *applied* and *fundamental,* the difference being one of aim rather than method. Work on problems for which the solutions have immediate application is

known as *applied research. Fundamental research,* on the other hand, consists of the systematic search for knowledge without reference to utility other than to advance the frontiers of knowledge and thereby supply the basis for further progress in the applied fields.

In a research project, the scientist must bring to bear all his own knowledge and experience related to the project, including reference to work done by other scientists in the same field.[1] He must devise a systematic approach to the problem, then formulate and experiment with his own theories and ideas.

Experimentation is the technical aspect of the scientist's work—the aspect we recognize most readily as being "scientific". Modern scientists have at their disposal a wide range of instruments and apparatus to make accurate observations and measurements, or to create the physical conditions needed for experimentation. They use radio telescopes to probe far beyond the range of ordinary telescopes; electron microscopes to investigate the secrets of the infinitely small. They may use furnaces that produce heat greater than the heat of the sun, or other apparatus that produces temperatures approaching absolute zero. They may use radioactive "tracer" elements to investigate the physiology of living things, or use their knowledge of radioactive disintegration to measure the age of rocks. Sometimes scientists have to design special equipment for their work; sometimes they adapt existing apparatus for special purposes.

It is not always possible for scientists to test their hypotheses in a laboratory. In astronomy and meteorology, for example, scientists have no way of controlling many phenomena they study. By *observation* they accumulate information that provides the basis for hypotheses which may be tested by further observation. When it is found that certain events occur according to a physical law, scientists have a valuable predictive tool at their disposal. *Prediction is the essence of science.*

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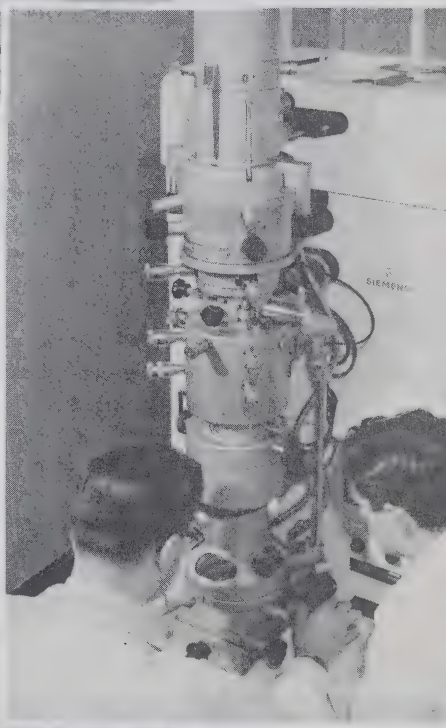
[1] The amount of scientific and technical data published in the world has reached tremendous proportions. Searching the literature, abstracting and indexing scientific papers for ready reference, has become an important function for many scientists. See also p. 18, "Women in Science" re *information specialist.*

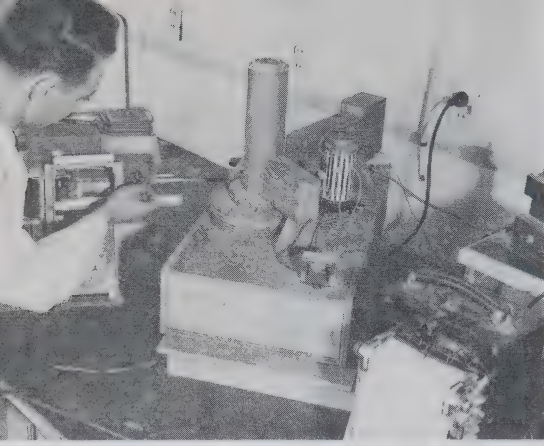
Photo: NFB



Modern scientists have at their disposal a wide range of instruments and apparatus. Above: Chief of the Stellar Physics Division of the Dominion Observatory, Penticton, B.C., heads up a team of scientists working with the huge radio telescope to study signals originating in outer space. Right: The electron microscope permits magnifications of up to one million times. Below: Studies in Low Temperature Physics. The Collins helium cryostat, which develops very low temperatures, may be seen in the background.

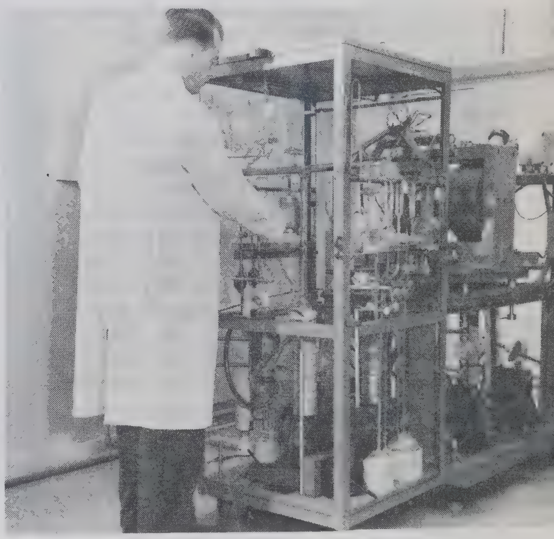
Photo: National Research Council

Photo: NFB



Scientists often have to design special equipment for their work. This "Curie Point" meter was designed for special studies on rock magnetism, an important part of research in geophysics.

Photo:
Geological Survey of Canada



A mass spectrometer is used at the Geological Survey to determine the absolute age of rocks and minerals.

Photo:
Geological Survey of Canada

Soil analysis—determining the available potassium in soil with an electrophotometer.

Photo:
Canadian Department of Agriculture

Although most research is done in laboratories, some scientists may spend much time in the "field", testing and experimenting under actual conditions, or gathering data and specimens.

Writing reports of their findings is expected of all scientists. In this way, new knowledge is recorded and is available to the rest of the scientific world. The scientist must first report to his employer, but he may also prepare technical papers for publication in scientific journals.

Communication of scientific information can be difficult, and the ability to write clearly and accurately is a very necessary skill.

Testing and Laboratory Work

Techniques similar to experimentation are employed in testing and laboratory work. In this case, scientists establish certain standards of quality for industrial products and work out techniques for testing them. Routine testing is usually done by technicians following procedures set up by scientists.

Consulting and Advisory Services

It is not always possible or practical for industrial firms, especially small firms, to maintain adequate laboratory facilities or staffs of scientists. For solutions to difficult technical problems they may engage the services of a consultant or refer problems to a commercial or government laboratory. Scientists who have specialized knowledge in a particular field often work, either part-time or full-time, in a consulting or advisory capacity.

Teaching and Extension Work

The teaching of science in secondary schools offers opportunities to those with a background of science, plus teacher training.[1] Such persons are identified primarily as teachers rather than scientists. The teacher with enthusiasm for science together with a capacity for intelligent and imaginative teaching can create the intellectual environment in which future scientists may find their vocation.

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[1] CANADIAN OCCUPATIONS Monograph No. 44, *Teacher*.

Science professors in universities are more readily identified as scientists. Many engage in research projects in addition to lecturing. Good students frequently serve as lecturers or laboratory instructors while working on graduate studies.

Extension work consists in interpreting the practical aspects of scientific information to the nonscientific public. Such work is most common in the field of agriculture, and is covered in more detail in the section "Science in Agriculture". Extension work is also becoming common in other fields as a result of the increasing importance of science to all aspects of daily life.

PERSONAL QUALITIES NEEDED FOR SUCCESS

> *I found that I was fitted for nothing so well as for the study of truth; as having a mind nimble and versatile enough to catch the resemblance of things . . . as being gifted by nature with desire to seek, patience to doubt, fondness to meditate, slowness to assert, readiness to consider . . .*

Sir Francis Bacon, writing of himself some 350 years ago, lists many of the personal qualities students who are thinking of a career in modern science should look for in themselves. They need a high order of intelligence and a willingness to study hard, in order to cope with the long and difficult preparation in university. They must have a lively—almost urgent—curiosity about the mysteries of nature and a desire to find answers.

They need patience to be painstaking and exact, and persistence to stay with a project, even when results are disappointing. Personal honesty and integrity are also important, for the scientist who deviates from this code in his work would eventually be found out and discredited.

Because scientific work is predominantly mental, a robust physique is not of prime importance. Yet the field work done in connection with geology, forestry or geophysics may involve heavy physical demands. Mechanical ability and resourcefulness are often needed to maintain and repair one's equipment and to cope with the rough life when isolated in remote areas. Modern transportation and better means of communication are making field work easier than it once was.

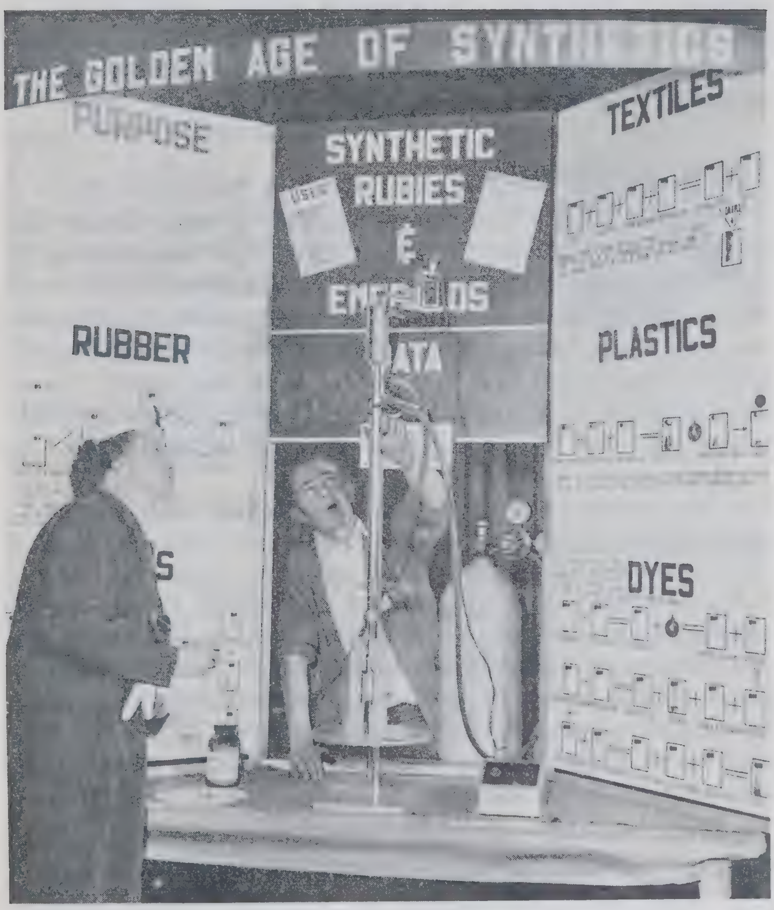

Photo: Canadian Industries Limited

Science fairs, relatively new to Canada, are growing in popularity as an effective way to provide young people with opportunities to test their talents and interest in chemistry, physics, biology and other sciences.

Students may not be certain of all these qualities in themselves. Many qualities develop with growing up; others are the result of long training. It is well, however, to make a careful personal appraisal. School studies, extracurricular activities, hobbies and reading interests may provide some clues. Good marks and special interest in science subjects, membership in science clubs, or participation in science fairs[1] may all be used as indicators of one's suitability for a science career.

Science or Engineering?

It may be difficult for students to decide between science and engineering as a career. Unlike engineers, who are interested in the *use* of things, scientists are more interested in the *nature* of things. They are more interested in seeking knowledge and understanding, leaving others (often engineers) to make practical application of the knowledge. The student who likes science but is more interested in designing, planning, building or operating things should look into the possibilities of a professional career in engineering.

Women in Science

Many more women are engaged in scientific work than in engineering, but they still comprise less than five per cent of the total number of Canada's scientists. Since the characteristics required of good scientists—intelligence, creative imagination, intuition, patience, curiosity—are shared equally by both sexes, it is apparent that women constitute a large, untapped potential for scientific work.

The field of biological science, followed by mathematics and chemistry, has attracted the greatest percentage of women scientists. Fewer women are attracted to agricultural science, forestry or geology, presumably because of the rigorous field work which is common to these sciences.

Women have made their greatest contribution in such aspects of science as research, teaching and extension work, editorial work,

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[1] Canadian Science Fairs Council has published a descriptive folder entitled *Science Fairs*, copies available free of charge from the Council's office at 48 Rideau Street, Ottawa, Ontario.

testing and laboratory services. Few have become engaged in design work, field exploration, production or administration. They have performed useful work as analysts, technicians, and research assistants. A growing field of opportunity for women with education in science, plus library training or experience, is work as *science librarians*. Another field is that of the *information specialist,* who assists other scientists by searching the literature for reports of current scientific developments, thus preventing unnecessary duplication of research effort.

Many women find successful and satisfying careers in science, although simply because they are women, they tend to encounter more obstacles and difficulties on the road to success than their male counterparts. Ambitious young women should expect their progress in a science career to be impeded to some extent unless they hold very high qualifications.

PREPARATION AND TRAINING

Secondary School

Most students intending to make a career in science can start basic preparation in secondary school by taking as many science courses as possible. Mathematics is particularly important; high achievement in this subject is considered by many to be a good prediction of success in the field of science. Because the fields of natural science are becoming more and more interdependent it is clear that a general, well-rounded background of science is a good foundation on which to build. A second modern language is almost indispensable and a third highly desirable for those who intend to do scientific research. A survey of the entrance requirements for university science courses indicates that senior matriculation, with credits in two or more high school science subjects, is necessary. Some Canadian universities accept high school graduates with junior matriculation, in which case the course leading to a bachelor degree is four years.

First Degree Science Courses at Canadian Universities and Colleges, 1961-62

Name of Institution	Agriculture; Agric. Eng.	Biochemistry—(Honours)	Biology—(Honours)	Botany—(Honours)	Chemistry—(Honours)	Food Chem; Food Tech.—(Hon.)	Forestry; Forest Eng.	Geology—(Honours)	Mathematics—(Honours)	Physics—(Honours)	Physiology—(Honours)	Science—(gen. or pass)	Zoology—(Honours)	Other Fields
Acadia University—Wolfville, N.S.			x		x			x	x	x		x		
University of Alberta—Edmonton, Alta.	x	x		x	x			x	x	x	x	x	x	Entomology—(Hon.); Genetics—(Hon.).
Assumption University of Windsor—Windsor, Ont.		x	x		x				x	x		x		
Bishop's University—Lennoxville, Que.			x		x				x	x		x		
Brandon College—Brandon, Man.												x		
The University of British Columbia—Vancouver, B.C.	x	x	x	x	x	x	x	x	x	x	x	x	x	Bacteriology—(Honours).
Carleton University—Ottawa, Ont.			x		x			x	x	x		x		Physics, Applied—(Honours).
Dalhousie University—Halifax, N.S.			x		x			x	x	x		x		
University of King's College—Halifax, N.S.			x		x			x	x	x		x		
Laurentian University of Sudbury (F&E)—Sudbury, Ont.												x		
Université Laval (F)—Quebec, Que.	x	x	x	x	x		x	x	x	x		x	x	Fisheries.
Loyola College—Montreal, Que.					x				x			x		
The University of Manitoba—Winnipeg, Man.	x	x		x	x			x	x	x		x	x	Actuarial Mathematics—(Honours); Microbiology—(Hon.); Statistics—(Hon.).
McGill University—Montreal, Que.	x	x	x	x	x			x	x	x	x	x	x	Bacteriology—(Hon.); Entomology—(Hon.); Genetics—(Hon.) Geophysics—(Hon.).
McMaster University—Hamilton, Ont.		x	x	x	x			x	x	x		x	x	Metallurgy.
Memorial University of Newfoundland—St. John's, Nfld.			x		x				x	x		x		
Université de Montréal (F)—Montreal, Que.	x	x	x		x			x	x	x		x		

Mount Allison University—Sackville, N.B.			x		x			x	x	x		x		
Mount Saint Vincent College—Halifax, N.S.												x		
University of New Brunswick—Fredericton, N.B.			x		x		x	x	x	x		x		General science—(Honours).
Ontario Agricultural College—Guelph, Ont.	x			x	x							x	x	Microbiology; Wildlife Management.
Université d'Ottawa (F&E)—Ottawa, Ont.		x	x	x	x			x	x	x		x		Natural history—(Honours).
Queen's University—Kingston, Ont.		x	x		x			x	x	x	x	x		
Royal Military College of Canada—Kingston, Ont.									x	x		x		
St. Dunstan's University—Charlottetown, P.E.I.												x		
St. Francis Xavier University—Antigonish, N.S.			x		x			x	x	x		x		
Université St-Joseph (F&E)—Saint Joseph, N.B.					x							x		
Saint Mary's University—Halifax, N.S.					x							x		
University of St. Michael's College—Toronto, Ont.		x	x	x	x	x		x	x	x	x	x	x	
St. Patrick's College—Ottawa, Ont.												x		
Collège Sainte-Anne (F)—Church Point, N.S.												x		
University of Saskatchewan—Saskatoon, Sask.	x	x	x		x	x		x	x	x	x	x		Histology—(Honours).
Université de Sherbrooke (F)—Sherbrooke, Que.					x							x		
Sir George Williams University—Montreal, Que.												x		
University of Toronto—Toronto, Ont.		x	x	x	x	x	x	x	x	x	x	x	x	
University of Trinity College—Toronto, Ont.		x	x	x	x	x		x	x	x	x	x	x	
Victoria University—Toronto, Ont.		x	x	x	x	x		x	x	x	x	x	x	
University of Waterloo—Waterloo, Ont.									x	x		x		
Waterloo University College—Waterloo, Ont									x					
University of Western Ontario—London, Ont.			x	x	x			x	x	x		x	x	Actuarial, Astronomical, Statistical Mathematics—(Hon.); Geophysics—(Hon.).

Source: Canadian Universities Foundation
(F) Language of Instruction—French.
(F&E) Languages of Instruction—French and English.

University Education

There are a few practising scientists who have attained their positions by long experience and hard private study without benefit of a university degree. However, the best route to a professional career in science today is through the university.

Types of undergraduate science courses available, ways in which they are organized, and prerequisites for graduate studies, vary from institution to institution. Students should consider carefully their long-range plans for higher education in science in order to make the best arrangement possible for their particular needs. Help should be sought from guidance counsellors, university calendars and university faculty members.

Those who want only a broad education in science usually take the *general pass degree* course, which requires three years of study after senior matriculation. As a terminal course, this leads to employment in scientific work at a junior or technician level, in technical sales and service, extension service, or (with additional teacher-training) teaching at the secondary school level. Students who do exceptionally well in the general pass course may be considered for admission to graduate studies provided they have standing in the necessary subjects.

Above-average students may choose the *honours degree* course, with specialization in a particular field of science. Honours courses are usually a year longer than pass courses; they are usually the course selected by students who plan to go on to graduate study. As terminal courses they lead to employment at a higher level than do pass degrees.

Postgraduate Degrees

To an ever-increasing extent graduate study, leading to a master's or Ph.D. degree, is necessary for advanced work and professional recognition in a science field. A master's degree consists of at least one year of study beyond an honours degree, or two years beyond a pass degree. A Ph.D. in science requires at least two years of study beyond the master's degree (at least seven years, and often longer, beyond senior matriculation). It consists of advanced studies on the frontiers of knowledge together

with work on an original research project on which a major thesis is written. An increasing proportion of scientists are going on to other universities or institutions for postdoctorate study.

Fees and Living Expenses

Approximate range of fees for tuition per year varies from \$200 to \$475, depending on the educational institution. Living expenses must also be considered, especially if one lives away from home. University calenders usually give information on fees, type of accommodation available, and approximate cost.

A biology class. Laboratory work is an important feature of university courses in the natural sciences.

Photo: NFB

Part of the expense of taking a university course can be met by earnings during summer vacations. There is also a steady increase in financial assistance for deserving students. Assistance is in the form of scholarships, bursaries and loan funds, details of which may be obtained from your school principal, vocational guidance counsellor, or from university calendars. A publication of the Dominion Bureau of Statistics, *University Entrance Awards,* describes all scholarships and bursaries of more than $100 in value open to high school graduates wishing to attend Canadian universities and colleges.

ENTRY AND ADVANCEMENT

During their undergraduate years and in summer jobs, science students will probably become increasingly aware of employment opportunities. They can obtain information about job openings from the Executive and Professional Division of the National Employment Service, which works in co-operation with placement officers in universities. Professional and scientific societies are also active in bringing scientists and employers together; some have student chapters, which facilitate entry into the occupation.

Technical journals, newspapers and company brochures often list opportunities in scientific and technical work. Positions in the federal Civil Service are filled by competition. Notices of openings are posted in public buildings such as post offices, local offices of the National Employment Service and the Civil Service Commission, and are published in the *Canada Gazette* and daily newspapers.

The level at which young scientists begin their careers and the rate at which they advance in scientific work is partly dependent on the level of education they attain. Postgraduate degrees are necessary for those who hope to do advanced research work. With experience (and continued study, which is a feature of most scientific work), increased responsibility, with greater challenge and reward, will follow. Those with the necessary ability, initiative and personal qualities may proceed to administrative and executive positions. Industry and governments are taking active steps toward creating ladders of advancement for outstanding scientists which depend solely on scientific capability without the need to assume administrative work.

EMPLOYMENT OF SCIENTISTS

Employment is most conveniently discussed under three main classifications: industry, government service, and education. A small number of scientists are employed in the Armed Forces and in business service (mostly consulting).

Industry

Nearly half[1] of Canada's scientists are employed in industry, where they are responsible for a wide variety of functions, including research and development, testing, inspection and laboratory services, technical sales and service, as well as production work and supervision.

Opportunities for research in industry are increasing although at present they are limited to large industrial firms. Industrial research is mostly concerned with production problems and development of new products. Basic or fundamental research in Canadian industry, for various reasons, has not as yet reached significant proportions.

Government Service

About one third of the scientists are employed by governments at provincial and federal levels, the federal government being the largest single source of employment. Scientific research has been supported primarily by the federal government, notably by the National Research Council and Defence Research Board. Federal and provincial departments of agriculture, health, and those charged with conservation and utilization of natural resources (minerals, forests, fisheries, wild life) maintain staffs of scientists to do fundamental research, work out technical problems, set standards of quality for industrial and agricultural products, and provide technical information services. Several provinces have set up scientific research councils or institutes of their own.

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[1] Unless otherwise stated, all statistical information in this monograph has been derived from the 1960 survey of a one-third sample of the scientific and technical personnel register maintained by the Department of Labour.

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The Field of Education

Approximately 20 per cent of Canada's scientists are employed in the field of education. Nearly two thirds of this group are employed by universities; the remainder by secondary schools.

All science graduates will have had the opportunity to see if the university atmosphere is to their liking. Those with post-graduate degrees who prefer to work with young people, and have a flair for teaching, may stay with the university, or return to a teaching post after some years of experience in government or industry. Many scientists find that the prospect of combining teaching with the chance to do some free and original research appeals to them.

There is demand for graduates in science to handle science courses in high schools, technical and vocational schools. In addition to a science degree (preferably an honours degree), a period of teacher-training is necessary. As science and technology become more complex, the need for good science teachers at this level will increase.

WORKING CONDITIONS

Most scientific work is done in laboratories, which vary greatly in size and facilities, according to the industry and the importance attached to research and development. Some laboratories are messy, or crowded with apparatus; others, because of the nature of the work, must be kept impeccably clean.

Each field of science has certain hazards which must be considered but in general, a scientific career is not thought of as dangerous. With precaution, any danger from handling explosive or poisonous chemicals, working with radioactive material, handling infectious material or irritants, can be kept to a minimum.

Earnings

New Graduates

Salaries received by 1959 graduates with bachelor degrees in science after one year of experience ranged from $4,000 to $6,400 per year. The great majority reported salaries in the $4,800 to

$5,600 range. (The ages of the graduates, and amount of work experience prior to graduation may be an important factor in the wide range of salaries earned. Although the majority of graduates were in the 21 to 25 year-old group, an appreciable number were 30 and over.)

With Experience

For the year 1960, the average earnings of science graduates five years after bachelor graduation were $6,250; 15 years after bachelor graduation, $8,350; 25 years after bachelor graduation, $9,250. Of course, those who have proceeded to postgraduate degrees report higher average earnings than those who have not.

Intangible Rewards

Early scientists were not salaried employees in the modern sense, and often their only reward for working in science was the satisfaction of their own curiosity and the enlightenment of mankind. Modern scientists may still get this satisfaction while earning a good salary.

Scientists belong to a world fraternity with a community of interests that cuts across race, colour, creed or politics. This is particularly apparent to scientists in universities and government service, who may visit, or be visited by, scientists of other countries. Scientists may establish world-wide reputations by having their research papers published in scientific journals.

Scientific progress in modern civilization is now so vitally important that scientists stand high in prestige and status; the "egghead" reference to scientists has quickly become a badge of respectability.

SCIENTIFIC ORGANIZATIONS AND LEARNED SOCIETIES

Since the formation in England of the Royal Society in 1659, followed by the Academy of Science in France in 1666, scientists have grouped together, according to their common interests, in a wide variety of organizations. Many of these are listed in the individual science sections to which they pertain.

Scientific organizations have numerous purposes. They promote interest in, and advancement of, their particular branch of science.

Scientific societies usually maintain a library and may publish a journal to inform members of new developments. They help coordinate research efforts and encourage the application of discoveries. Some societies set up standards of professional qualification for their members and assist new entrants to find employment.

Membership in some societies is restricted, and is achieved only by invitation, or by meritorious work in a field of science; others are mainly interest-groups, with a large lay (nonprofessional or amateur) membership. Societies may have various levels of membership, from fellows and full members to associate members. Undergraduate students may join some societies as student members.

OUTLOOK FOR SCIENTISTS

Demand for scientific personnel is fairly stable and based mainly on long-term planning. The work is predominantly of a research nature, which is not greatly affected by short-term fluctuations in economic activity. In addition, half of Canada's scientists are employed by government or educational institutions, and services provided by both these sectors are fairly independent of changes in the level of business activity.

Science and technology have advanced dramatically in the last twenty-five years. They will move forward faster in the future, with no stopping point yet in sight. Although advances have not been quite so dramatic or on as wide a front in Canada as in some other countries, the impact of scientific and technological development has been significant.

Requirements for scientists in Canada during the last twenty-five years are estimated to have more than doubled. During the last five years the annual increase in the number of new jobs opening up which required scientific personnel has averaged somewhat over five per cent. It appears reasonably certain that the demand for scientists in the years ahead will continue to increase at least at the same rate.

This is the broad estimate of demand for all scientists for the years to come; some variations in the strength of demand between the individual science fields can be expected.

Distribution of Scientific and Technical Personnel Register by Undergraduate Science Course,[1]

June 1961

Agriculture	7,955
Forestry[2]	2,665
Bacteriology	156
Biochemistry	356
Biology	980
Botany	129
Chemistry	4,362
Chemistry and Physics	418
General Science	6,003
Geology	1,712
Mathematics	751
Mathematics and Physics	1,769
Metallurgy	52
Physics	986
Zoology	333
Other[3]	377
Total	29,004

[1] The above figures are based on a count made during the week ending June 9, 1961 of individual files in the scientific and technical personnel register maintained by the Department of Labour, Ottawa, Canada. The 1961 graduates are not shown.

[2] Includes forest engineering.

[3] Includes various combinations of honours courses.

NOTE: Many graduates go on to take postgraduate work, or find employment, in a field other than their undergraduate course.

II

PHYSICS[1]

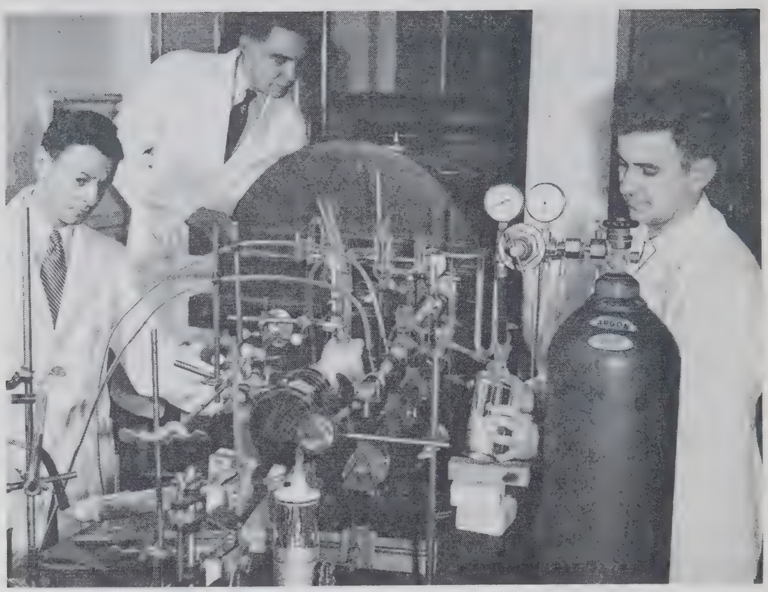

Photo: NFB

Postdoctorate Fellows from Canada, Great Britain and the United States working together in the spectroscopy laboratory, Division of Physics, National Research Council, Ottawa.

Physics deals with the states and properties of matter, with energy and motion, and the natural laws and processes governing the physical universe. It now includes studies of mechanics, heat, light, sound, electromagnetism, electronics, atomic and nuclear physics, and properties of materials. It also includes study of living matter and physiological processes in the field of biophysics; chemicals and chemical processes in the field of chemical physics, and properties and character of the earth and forces acting upon it in the field of geophysics.

[1] Read first, Section I "Science in General".

Historically, man's inventive genius has made good use of scientific principles without necessarily understanding them. Early use of the lever, the wheel, and the forces of water, wind, gravity and heat, illustrates a rudimentary technology without science.

Attempts to explain the nature of phenomena such as these led from natural philosophy to physical science, the parent of physics. When the behaviour of matter and energy was found to take place according to certain relatively fixed laws, it could be better understood and, what's more, *predicted*. Technology provided more refined and accurate instruments, making possible further scientific discovery.

In the last 150 years, many major discoveries and inventions in physics have helped transform men's lives. Outstanding examples are the discovery of X rays by Roentgen; radioactivity by Becquerel; disintegration of the atom by Rutherford; electromagnetic induction by Faraday; and the electron by J. J. Thomson. These and other discoveries led to development of the dynamo, electric motor, radio, telephone, aviation, refrigeration, and motion pictures. Dramatic advances were made during World War II with radar, rockets, jet aircraft, and the atom bomb.

Since then, whole new vistas of technology, based on the principles of physics, have opened up. Development of atomic fusion, nuclear-powered ships, guided missiles, earth-orbiting man-made satellites, and—the dream of science-fiction writers for many years—the exciting possibility of interplanetary space travel, have come with breath-taking swiftness.

AREAS OF SPECIALIZATION

Physics is predominantly a research field, both pure and applied, and because of its scope, is divided into areas of specialization. Each includes subareas in which research is being done. Following are the main areas, with examples of the technological applications emerging from research.

Mechanics

Supersonic flight and the space age have introduced new problems relating to aerodynamics, ballistics and jet propulsion. Studies in the flow of solid matter under pressure (rheology) have led to

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new metal-forming techniques. Automation and material-transfer equipment are concerned with hydrodynamics, mechanical instrumentation and measuring devices.

Acoustics and Sound

This area includes studies in the propagation, transmission, measurement and analysis of sound; ultrasonics; amplification, reproduction and recording of sound. Practical applications of such research include control of industrial noise and nondestructive testing of materials.

Light and Optics

Research in light and optics covers another important area in physics and includes studies of sources and origin of illumination; spectroscopy; colorimetry; photography and polarized light. Light waves are now being used to set standards of measurement. Experiments with a device called an Optical Maser indicate that scientists may eventually control light waves to make possible a radically new method of multichannel telecommunication.

Electricity and Magnetism

Achievements in this area have already revolutionized modern society. Recent studies include the possibilities of long-distance transmission of electricity at ultrahigh voltages, and the development of ultrapowerful electromagnets by passing current through coils of special alloys made superconductive by very low (cryogenic) temperatures.

Electronics

Almost a separate science in itself, electronics promises to set the pace for future research and discovery. The heart of this area lies in the electron tube and the more recently developed solid state devices (transistors). Research also goes on in the propagation of radio waves and the study of their behaviour, and design of antennae and transmission lines. Recent practical applications of electronics are multichannel microwave networks, electron microscopes, radio telescopes, rocket and missile control systems, electronic data processing equipment, and a host of others. Solid state physics is another new and fast-developing area of research and includes work on crystals, dielectrics, magnetic phenomena, semiconductors, electroluminescence and thermoelectrics.

Heat

Research in this area includes studies in heat radiation and transmission, kinetic theory, thermodynamics, thermal properties of matter, and high-temperature phenomena.

Nuclear Physics

Explosion of the first nuclear device less than twenty years ago was the culmination of intensive research spurred on by wartime necessity. It opened up tremendous possibilities for new sources of energy for a power-hungry world and created new problems in the control of chain reactions, radiation and fallout, and utilization of atomic energy for peacetime purposes. Structure and properties of matter, X rays, cosmic rays, effects of radiation on matter, nuclear reactions and radioactivity are important areas of research.

Astronomy

Astronomy is a science in its own right, with its own organized body of knowledge about the earth and the universe. One of the oldest of sciences, it is forging ahead, using all the other natural sciences to extend our knowledge of the heavens.

Because the position, movement and composition of celestial bodies are governed by physical laws, *astronomers* must be well versed in the science of physics and mathematics in order to understand such phenomena. Use of the spectrometer to determine the nature of stars, and the development of radio astronomy, are examples of the close relationship of physics to astronomy.

Astronomers are employed mainly by the Dominion Observatory for astronomical research, and by universities for research and teaching.

Meteorology

This is the branch of physics that treats of the atmosphere and its phenomena. It has practical application in weather forecasting and climatological information, but research is going on in connection with long-range weather forecasting, weather control (rainmaking and hail-prevention), air pollution, studies of the upper atmosphere, and use of electronic computers in weather forecasting.

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Meteorology, like astronomy, has its own career possibilities, the chief employer being the Meteorological Service of Canada. Honours graduates in mathematics and physics, or engineering physics, may qualify for a professional position in the Service. While on salary, they are required to take further university education leading to a master's degree in meteorology[1].

NATURE OF THE WORK

Since physics is predominantly a research field, it follows that more physicists are engaged in research and development than in any other single function. The physicist in fundamental research will find himself involved in the theory and technicalities of one of the many areas of physics listed above, so complex as to be difficult to describe to the uninitiated. In applied research and development, he will seek solutions to highly technical problems arising in industry and the field of medicine.

It is the emphasis on mathematical methods that sets physics apart from other sciences. Yet it would be an error to think of a physicist as an applied mathematician; experimental demonstration of physical laws and processes is the only authority recognized by the physicist.

Teaching is another major function for many physicists. In the university setting they may combine lecturing and instruction with work on research projects.

PERSONAL QUALITIES NEEDED

Physics is perhaps the most rigorous and exacting of the sciences, and will challenge the efforts, intelligence and imagination of the best students. Most universities recognize this and require higher grades for admission to their physics courses than for other science courses. Ability in mathematics is basic as a requirement.

Students whose interest is in physics, but who are attracted to an engineering career might consider the possibility of a course in engineering physics. Here the line between science and engineering has all but vanished, where the study of fundamental laws

[1] CANADIAN OCCUPATIONS Monograph No. 43, *Careers in Meteorology.*

governing the behaviour of matter and energy finds practical application in industrial processes and the design of structures, machines and other technical equipment.

PREPARATION AND TRAINING

High school students preparing for a career in physics should take as many science courses as possible. Mathematics, including algebra, geometry and trigonometry, is important, as it is the language of physics.

A bachelor's degree, with a major in physics, is a minimum requirement. It is possible to arrange a course that includes physics *and* mathematics, or physics *and* chemistry as a major concentration. Advancement in physics is difficult, however, without a master's degree or a doctorate. More than half (60 per cent) of the scientists surveyed, who were in the field of physics, had obtained at least one postgraduate degree. The American Institute of Physics has established as a minimum requirement for qualification as a professional physicist, eight years training and experience in the field.

EMPLOYMENT OF PHYSICISTS

Nearly half of Canada's physicists are employed in government research, the federal government being by far the most important source of employment.

Nearly one third are employed in the field of education, mainly in universities, but also in high schools.

The number of physicists employed in private industry is not great as yet, but could increase as technology becomes more complex and industry does more of its own research. An appreciable proportion of physicists are working as consultants.

OUTLOOK

Physics has been basic to the dramatic developments of atomic energy, radar, rockets and guided missiles. Even greater advances are expected in the future. Demand for physicists will continue its rising trend and they will be among the fastest-growing professions.

ORGANIZATIONS

Canadian Association of Physicists, Department of Physics, McMaster University, Hamilton, Ont.

Royal Astronomical Society of Canada, 252 College St., Toronto 2B, Ont. With 16 autonomous centres in Canadian cities.

ADDITIONAL READING

Books

Dietz, David. *Atomic Science, Bombs and Power* (*Civilisation de l'atome*). New York, Dodd Mead & Co. 1954. 316 p.

Covers such topics as the atomic and quantum theories, the nature of energy, nuclear fission, the atomic bomb, radioactive isotopes and the peacetime possibilities of atomic power.

Lavine, Sigmund A. *Steinmetz—Maker of Lightning*. New York. Dodd Mead & Co. 1955.

Peare, Catherine O. *Albert Einstein*. New York. Holt & Co. 1949.

Pollock, Philip. *Your Career in Physics*. New York. Dutton & Co. 1955.

Covers careers in atomic energy, aeronautical research, power production, meteorology, etc.

Rousseau, Pierre. *Les satellites artificiels*. Paris. Hachette. 1957. 191 p.

A narrative on space travel, the problems of astronauts, and the conquest of new worlds.

Bulletins and Pamphlets

Guidance Centre, Ontario College of Education. Toronto.

Monograph: *Physicist* 1962.
Meteorologist 1959.
Astronomer 1958.

Canadian Association of Physicists. *Physics in Canada—a Career, a Vocation* (*La physique au Canada*). McMaster University. Hamilton, Ont.

Pamphlet on what it means to be a physicist in Canada.

Dominion Bureau of Statistics. *Astronomy in Canada*. (Reprint from *The Canada Year Book* 1956). Ottawa.

History and development of astronomy in Canada.

III

CHEMISTRY[1]

Chemistry is that branch of knowledge which deals with the composition of substances. It is concerned with the properties of matter and the laws that govern the combination of elements to form an infinite variety of materials.

[1] Read first, Section I, "Science in General."

Photo: Imperial Oil Limited

Wax making was once an art, but modern research has turned it into a science. Here, a chemist tests new waxes that have been developed using a hydrofining process.

FIELDS OF CHEMISTRY

Traditionally, chemistry has been divided into two main branches, based on the kinds of substances (organic or inorganic) studied by each branch.

Organic Chemistry is the branch concerned with the study of substances which are derived from living organisms or have the element carbon as a constituent part of their composition. These include proteins, sugars, starches, fats, enzymes, and petrochemicals, etc. When chemists discovered how to synthesize organic substances from inorganic material, this branch of chemistry expanded to include synthetics such as plastics, dyes, paints, rubber and textile fibers. It has become so complex that *organic chemists* may specialize in the study of specific types of organic substances, such as carbohydrates, enzymes, or petroleum.

Inorganic Chemistry deals with substances made up of one or more of the other 100-odd elements but which do not, as a rule, contain carbon. These include metals and their compounds, nonmetals, such as sulphur, and their compounds, and inorganic acids.

There are numerous approaches to chemistry that are areas of specialization for chemists. In *biochemistry,* the reproduction, growth and metabolism of living organisms are studied in terms of chemistry. This field includes food chemistry, fermentation chemistry, bacterial chemistry, chemical endocrinology and the preparation of sera, vaccines, and hormones. *Physical chemistry* is concerned with the laws of physics that govern chemical change in all substances; electrochemistry, photochemistry, thermodynamics, radio chemistry are examples. Another important area of specialization is *analytical chemistry*.

NATURE OF THE WORK

In general, chemists perform research and development work and carry out tests, experiments and analyses relating to the composition and properties of, and possible changes in, substances in the field of chemistry. They investigate basic properties and structure of substances and the transformations they can undergo; apply known laws, principles and methods to discover and develop new chemical products, new uses for existing products, and new methods of production. They work out solutions to industrial

chemistry problems such as quality control and analysis of raw materials and finished products. They may supervise other workers in laboratory investigations or in industrial processes involving chemicals.

Individual chemists tend to specialize in one or more of the functional areas mentioned in the general section (page 11). About 40 per cent are engaged in research and development and 20 per cent are engaged in testing, analysis and laboratory service. Some are engaged in production processes, although this is primarily the work of chemical engineers. Teaching chemistry occupies about 15 per cent of the chemists; a smaller percentage are engaged in technical sales, service and marketing. Other specializations include patent work, consulting and administration.

Chemists work with a great variety of apparatus. In addition to the assortment of equipment common to high school laboratories, they may use, depending on their work, a variety of glassware (some of which they may make themselves), electronic and mechanical apparatus for measurement or for providing the physical conditions under which reactions take place. They may improvise and construct special apparatus, often relying on laboratory assistants to set it up or to carry out the procedures and make observations, calculations or tabulations of results. They often work out the details of tests and analyses, but once the procedure is established, routine tests are carried out by laboratory technicians, or by automatic and recording devices. Chemical industries with continuous-flow processes (as opposed to batch processes) lend themselves to certain forms of automation which involve complex instrumentation.

PERSONAL QUALITIES NEEDED

For persons who meet the general qualities expected of scientists, the decision to select the field of chemistry for a science career can, perhaps, be based on one's experience with chemistry in high school.

Since chemistry often deals with minute quantities, as well as complex formulae and symbolic representation of chemical reactions, one should be capable of painstaking accuracy, the ability to think in abstract terms, and have a facility for devising and assembling apparatus.

Those who are interested in knowledge for its own sake are more likely to find satisfaction as research chemists. Those who prefer to work on the production of things, and in the practical application of knowledge, are more likely to find satisfaction in applied research or as chemical engineers. Work in sales requires good business sense and the ability to deal with people.

PREPARATION AND TRAINING

As chemistry is an exact science, a good grounding in high school mathematics is necessary, as well as chemistry and physics. A second modern language (German or Russian) is almost indispensable and a third is highly desirable. In this age of rapid development and wide-scale application of science, the need for a good knowledge of the scientific literature of other countries is extremely useful to all scientists, especially those engaged in research.

It is practically impossible to achieve professional standing as a chemist without a university degree. A recent survey by the Department of Labour revealed that of 891 chemists, 60 per cent had a bachelor degree; 15 per cent had a master's degree; and 25 per cent, a doctorate. According to the Chemical Institute of Canada, at the present time about half of the students who take chemistry continue on to postgraduate degrees. This indicates the importance placed on postgraduate work.

EMPLOYMENT OF CHEMISTS

Few chemists set up private practices as do medical doctors, lawyers, or architects. Most chemists work for large organizations such as manufacturing companies, government laboratories or educational institutions. These are almost always located in or near large centres of population, so that the typical chemist is a salaried man living in an urban community.

Opportunity for a wide variety of fundamental and applied research in all fields of chemistry exists with departments and agencies of the federal government. Nearly 20 per cent of Canada's chemists are employed by governments of all levels.

In private industry, opportunities for chemists are more likely to lie in applied research, testing, production, quality control, or

in technical sales and service. There is somewhat less opportunity or freedom to follow one's personal inclinations in fundamental research. Nearly 65 per cent of the chemists in Canada are employed in private industry, including some in business service and consulting.

Nearly 20 per cent of the country's chemists are employed in the field of education. Most university professors of chemistry are actively engaged in research projects, in addition to lecturing. Some are engaged entirely in research, often on a fundamental problem of their own choosing.

There is a need for people with a background of chemistry, as well as teacher training, to handle high school courses in chemistry.

OUTLOOK

In the past 20 years the chemical industry in Canada has expanded at a rate sufficient to overshadow short-term fluctuations in its levels of activity and output. As a result, the long-term trend of scientific employment in the industry has been steadily upward. Outlook for production and research in the chemical industry for the next ten years suggests rates of increase matching that of overall scientific developments in the country and a demand for chemists comparable to those of the past few years.

ORGANIZATIONS

Chemical Institute of Canada, 48 Rideau Street, Ottawa, Can. (More than 30 local organizations and 30 student chapters)

Association of Professional Chemists of Quebec, P.O. Box 125, Station B, Montreal, P.Q.

ADDITIONAL READING

Books

Battista, O. A. *The Challenge of Chemistry*. Toronto. Winston & Co. 1950.

Irwin, K. G. *The Romance of Chemistry from Ancient Alchemy to Nuclear Fission*. New York. Viking Press. 1959.

Massain, Robert. *Chimie et chimistes*. Paris, School Editions. 1952. 392 p.

Pollock, Philip. *Careers and Opportunities in Chemistry*. New York. Dutton and Co. 1960. 147 p. Illus.

Warrington, C. J. S. and R. V. V. Nicholls. *A History of Chemistry in Canada*. Toronto. Pitman & Sons. 1949.

Bulletins and Pamphlets

Guidance Centre, Ontario College of Education. Toronto:
Monograph: *Chemist* 1959.
Metallurgist 1961.

Chemical Institute of Canada. Ottawa.
Your Career as a Chemist (*La carrière de chimiste*) 1958.
Your Career as a Chemical Engineer. (*La carrière d'ingénieur chimiste*) 1958.

Cragg, L. H. *The Professions of Chemistry and Chemical Engineering in Canada.* Ottawa. Chemical Institute of Canada. 1950.

"Le Royaume de la chimie", collection *Jalons.* No. 238, May 1960. École de Pédagogie et d'Orientation, 71 d'Auteuil, Québec, P.Q. Defines duties, fields of specialization and personal qualifications required.

Ouellet, C. "La chimie au Canada", in *Culture* XIII. December 1952. p. 363-374.

IV

GEOLOGY[1]

Geology is the study of the structure, composition and history of the earth. Rocks, soils, earthquakes, volcanic eruptions, glaciers and other earthly phenomena all come within its scope.

[1] Read first, Section I, "Science in General".

Photo: NFB

Geologist, in search of oil, calculates the land's contours in the Rock Lake area of the Alberta foothills.

Study of the earth involves a combination of many natural sciences. These are known collectively as the *earth sciences* or *geosciences,* and include *geophysics, geochemistry,* and *geobiology* (better known as *palaeontology*), as well as the parent science geology.

Systematic geological exploration and study of Canada started with the organization of the Geological Survey of Canada in 1842. It has been continued ever since by the federal government, complemented by that of provincial geological surveys or departments of mines, and by private individuals and corporations.

The International Geophysical Year, initiated in 1957, was undertaken to study, in particular, the oceans and atmosphere of the earth. Scientists from all over the world took part, and from pole to pole, from the depths of the deepest ocean to the highest point in the atmosphere—and beyond—the full force of modern science was marshalled to gather data and information that will take years to analyse. Another international project, called the Upper Mantle Project, is the study of the upper part of the earth's interior. This project is actually an extension of the International Geophysical Year but with the emphasis changed from the study of the fluid envelope of the earth to study of the solid earth itself.

THE GEOSCIENTISTS

Geologists

In Canada, most *geologists* are concerned directly or indirectly with locating deposits of metals, oil, natural gas and other minerals of economic importance. Their work and studies are of value in this because the different mineral resources are associated with characteristic geological environments. Knowledge of the rocks of the earth's crust, recorded in geological reports and maps, is thus a guide to where to look for the materials we need. For this reason the work of the geologist is done mainly in the field. It ranges from reconnaissance surveys (to complete the initial geological mapping of Canada) to very detailed mapping of mining properties and oil structures. Work begins with mapping of bedrock and soils, just as the topographer maps roads, buildings and

other surface features. Different kinds of rocks, minerals and other materials collected in the field are identified and studied through additional laboratory research on their various chemical and physical characteristics.

In such a broad field, specialists concentrate their activities in certain defined areas. *Palaeontologists* and *stratigraphers* study the layers or beds of sedimentary rocks, identify and classify the fossil remains of animals and plants of former geological periods that are preserved in them. Such knowledge not only tells much of the history of the earth over the past 500 to 600 million years but is also of practical use in the search for oil, natural gas, coal and other valuable minerals. *Petrologists* and *petrographers* investigate the rocks forming the earth's crust, the minerals that compose them, and their origin.

Mineralogists examine, analyse and classify minerals and precious stones according to their composition and structure. *Economic geologists* are specialists in finding and developing mineral deposits such as gold, lead, copper, etc.; *petroleum geologists* are economic geologists who explore and chart the layers of sediment and rocks in search of accumulations of oil and natural gas. Economic geologists have made an important contribution to the development of Canada's mining and petroleum industries.

Geomorphologists study the changes in the earth's surface brought about by sedimentation, erosion and glaciation—the forces of nature that create changes in the landscape.

In engineering, the geologist advises on soil and subsoil conditions as they affect the construction of large buildings, dams, tunnels, etc.

Ground water geologists find the water-bearing layers (aquifers) in rocks and soils, and determine their extent and the amount of water they may yield.

Other areas of specialization include structural geology, volcanology (the study of volcanoes and volcanic rocks), isotopic and nuclear geology. Geologists may specialize also in the study of rocks of specific geological periods ranging from the Precambrian (the oldest) to the Pleistocene (the most recent).

Geophysicists

Geophysics is an example of two science disciplines combining to form a new and important area of investigation. It is the application of physics and mathematics to study the earth, including its atmosphere, oceans, magnetism and gravity, etc.

In general, *geophysicists* utilize their knowledge of physics and mathematics, and a variety of complex measuring devices such as seismographs, magnetometers, gravimeters and spectrometers, to study and measure seismic, gravitational, electrical and thermal phenomena. Thus they aid in finding out more about the structure and composition of the earth and the forces causing movement and warping of its crust.

Geophysicists also specialize. They may investigate the phenomena of earthquakes (*seismologists*); take measurements concerning the shape of the earth and its gravitational forces (*geodesists*); aid geologists find mineral deposits or study the structure of the rocks of the earth's crust by means of seismic, magnetic and other measurements (*exploration geophysicists*).

Oceanography

Geologists participate in oceanographic studies. Oceanography is the study of the sea, including not only the study of the characteristics of the sea water itself, but the boundaries of the ocean, shape of the coastlines, nature of the ocean floor and the interaction of the sea with the air above it. In addition, oceanographic studies include biological investigations of life in the sea. Geologists, geophysicists, geochemists and biologists all have important roles in oceanographic studies and there is, at the moment, an acute shortage of persons qualified for this work.

NATURE OF THE WORK

Geologists may be divided roughly into two groups. The first group includes the geologists who are directly concerned with the search for and development of ore deposits and oil and gas fields. They are economic geologists or geological engineers. The second group includes geologists who study the history of the earth, the distribution, structure and origin of the rocks and of the valuable

minerals they contain. These are the geological scientists or "research geologists", and they furnish the basic knowledge used by the geological engineer. But there is no sharp division between the two groups, and many geologists who at first are engaged in the more purely scientific aspects of geology later become economic geologists or geological engineers.

In prospecting and exploration work the economic geologist, the geochemist and the geophysicist work together as a team. The geologist maps the rocks and, aided by the data obtained by the geophysicist and geochemist, he outlines the structures most likely to contain oil and deposits of valuable metals or other materials. Exploratory drilling is based on his reports. The geologist is also in charge of initial development of deposits. He directs the diamond drilling and, from the examination of the drill cores, estimates the size and grade of the buried ore body. If it is big enough and rich enough the geologist advises his company on developing it as a mine. Throughout the life of the mine his detailed geological mapping is the basis for the exploration and development that determines the ore reserves of the mine in advance of production.[1]

Geological scientists are concerned with more fundamental aspects of the science. They are concerned with mapping the basic geological facts about areas. Such maps, and the reports that accompany them, are indispensable in helping economic geologists and prospectors choose areas in which to work and in guiding them in the field. They are also indispensable for the interpretation of geophysical data. Geological scientists deal with the distribution and mode of formation of the rocks of the earth's crust, their structure, and how and why the mineral deposits and oil pools in them originated. They supply the basic data which is applied by economic geologists in the search for and development of our mineral resources. They are employed by the federal and provincial departments of mines, on the teaching staffs of universities, by museums and by some of the larger oil companies.

PERSONAL QUALITIES NEEDED

In addition to the usual requirements of a scientist discussed in the general section, a successful and satisfied geoscientist must

[1]CANADIAN OCCUPATIONS Monograph No. 14, *Mining Occupations.*

have a keen interest in the subject matter of geology—minerals and rock formations—and be intrigued by the romance and mystery of the earth's evolution. With the possible exception of those who might be attracted to careers in basic research in geoscience, carried out mainly by government departments and agencies, most geologists need a good sense of the economic importance of geology and be willing to spend some time on this aspect of the work.

Good health and a liking for outdoor life, sometimes under difficult conditions, together with an adventurous spirit, are necessary for work in geology. The need to travel, often to the far north and other remote areas, has disadvantages for those who have strong home or family ties, or dislike unfamiliar surroundings or isolation.

PREPARATION AND TRAINING

Twenty-two universities across Canada offer first degree, honours, and graduate courses in geology. A number offer a combined honours course in physics and geology as a specialization.

Greater emphasis is now being placed on the continuation of studies toward a master's degree or a doctorate in geology, with more work on chemistry, physics and mathematics. Approximately 45 per cent of the geoscientists surveyed by the Department of Labour in 1960 had a master's degree or a doctorate.

On the whole, students are cautioned against specialization in fields that are too narrow, especially in their undergraduate studies, and urged to gain thorough and broad training. Specialization should be left to graduate studies.

During one's training, a course in field geology (geological mapping and interpretation) for practical application of theoretical knowledge, is recommended, and most universities require such a course. Summer jobs in the field are important in the training of the student geologist. Many students are employed as student assistants on federal and provincial geological surveys and field parties, where they obtain valuable training in the application of geological principles.

OUTLOOK

Geological science has been tied closely to the economic development of mineral deposits. The history of Canadian mining has been one of ups and downs, following both spasmodic market demands for specific minerals, and equally erratic discovery and development of new deposits. Much of the geologists' work is in field exploration, which is directly related to the level of operation of the industry and follows its erratic characteristics. Mining activity in Canada has been easing off during the past few years. This situation could, of course, change very quickly but present conditions indicate no great increase in demand for geologists.

ORGANIZATIONS

Geological Association of Canada, Box 4029, Terminal A, Toronto, Ontario.

Canadian Institute of Mining and Metallurgy, 906 Drummond Building, Montreal 2, P.Q.

Mineralogical Association of Canada, 300 LeBreton Street, Ottawa, Ontario.

Alberta Society of Petroleum Geologists, 401 Natural Gas Building, Calgary, Alberta.

Saskatchewan Geological Society, Box 234, Regina, Saskatchewan.

ADDITIONAL READING

Books

Carson, Rachel L. *The Sea Around Us* (*Cette mer qui nous entoure*). Toronto. Oxford University Press. 1951.
The nature of the sea and the living things in it.

Furon, Raymond. *Mers, glaciers, volcans*. Paris. Larousse. 1958. 103 p.
A beautifully illustrated book describing many earthly phenomena.

de Latil, Pierre. *Du Nautilus au bathyscaphe*. Paris. Arthaud. 1955. 187 p.
Factual account of underwater life of man and fish.

Shaw, Margaret M. *Geologists and Prospectors*. Canadian Portraits series. Toronto. Clarke Irwin & Co. Ltd. 1958. 190 p.
The life and work of Tyrrell, Camsell, Cross and LaBine.

Bulletins and Pamphlets

Baird, David M. *A Guide to Geology*. Ottawa. Queen's Printer. ($1.00).
Designed as a handbook for visitors to Canada's National Parks. It describes basic features of the earth's crust and geological processes that create majestic mountains and mighty rivers.

Guidance Centre. Ontario College of Education. Toronto.
Monograph: *Geologist* 1958.
Oceanographer 1961.
Geophysicist 1960.

Tully, John P. *Oceanography—Science of the Sea* (*L'océanographie—science de la mer.*) (Reprint from *Canadian Geographical Journal.*) Ottawa. Queen's Printer. 1953. 19 p. (25¢).
An account of work being done by Canada in this field.

V

MATHEMATICS[1]

"Mathematics is the science that includes arithmetic, algebra, and trigonometry. It treats of the exact relations existing between numbers, quantities, magnitudes or operations, and of the methods by which, in accordance with these relations, quantities sought are found from others known or supposed."[2]

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[1] Read first, Section I, "Science in General".

[2] C. H. McDowell, *A Short Dictionary of Mathematics.*

Photo: NFB

Mathematicians are much in demand because results derived from experiments are sometimes at variance with results predicted by theory. When this happens, scientists have the complex and delicate job of finding out whether the fault lies in the theory or the experiment—or both!

Most scientists are adept mathematicians, and the importance of mathematics to physics has been mentioned in Section II. But just as there are specialists in other fields, so there are scientists who specialize in mathematics. As a science, mathematics offers its own group of related career opportunities, and it is the purpose of this section to examine some of the major ones.

MATHEMATICS AND MATHEMATICIANS

Mathematicians solve, and direct the solution of, complex mathematical problems related to scientific research and development, engineering, and economic activities. As consultants, they advise on the various applications of mathematical analysis. They may devise new or improved methods for applying mathematical theory and analysis to scientific research or economic problems. Many specialize in a particular branch of mathematics, or in the mathematical aspects of other branches of science, or of economic activities such as industrial production, insurance, or business forecasting.

Areas of specialization include actuarial mathematics (*actuaries*); biological mathematics (*biometricians*); mathematics of physics and chemistry; mathematical statistics (*statisticians*); numerical analysis, including tables, mathematical instruments and computers; theory of probability (*statisticians* and *actuaries*).

Statisticians are concerned with the collection, tabulation, analysis and interpretation of masses of numerical or quantitative data. In contrast with the main stream of mathematics, which has developed over the centuries, statistics is a relatively new tool. It provides scientists with formulas and techniques to arrive at useful conclusions about the characteristics of a group; to compare the relationship of one set of data to another; to establish, out of masses of data or information that might otherwise be meaningless, the existence of trends and cycles from which future events may be predicted. Such relationships or characteristics are expressed as averages, medians, percentiles, ratios, correlations, probabilities, etc. Statistical information may be presented in the form of charts, graphs, diagrams or written summaries.

NATURE OF THE WORK

Research in Mathematics

In the field of theoretical or pure mathematics, mainly in the universities, mathematicians are concerned primarily with research and experiment which may not have any immediate application but advance the frontiers of mathematical knowledge.

Applied Mathematics

The applied mathematician often finds himself in the company of other scientists and engineers where, as a member of the team, his special skill is used to provide mathematical solutions to complex scientific and engineering problems. He must be reasonably familiar with the field in which he is working, e.g., biology, physics, chemistry, engineering, etc., if he is to understand the nature of the problems with which he must deal.

Mathematicians do not require supportive equipment or apparatus to the same degree as their colleagues in natural science or engineering. Their main tool is knowledge of mathematical techniques and their application. To an increasing extent, however, they are using the fantastic potential of analogue and digital computers. These electronic machines, when programmed, can solve complex scientific and engineering problems and tabulate masses of data quickly and accurately. The program of instructions must be prepared in great detail by human mathematicians, after which the machine can carry out the routine drudgery.

PERSONAL QUALITIES NEEDED

Mathematics is an exact science, and its practitioners must be, by nature, precise and exacting, logical in their thinking, imaginative and inquisitive. Unusual success and satisfaction in high school mathematics courses might be taken as an indication that a student is suited for a career in mathematics. However, since applied mathematics is usually practised in connection with problems related to other sciences, engineering, business or industry, secondary interests and abilities should also be considered. The mathematics of physics and chemistry, for example, would require considerable knowledge of these two sciences.

PREPARATION AND TRAINING

Because of the dominant role of mathematics in most sciences and in engineering, many graduates from these courses are, as a result, quite competent in mathematics.

Most Canadian universities offer pass and honours courses with mathematics as a major, and larger ones offer graduate courses. Combined majors of mathematics and physics are also available and lead to a variety of careers in science or engineering.

EMPLOYMENT OF MATHEMATICIANS

Surveys by the Department of Labour show that the proportion of mathematicians engaged in teaching increased from 50 per cent in 1954 to 66 per cent by 1960. The proportion engaged in research and development declined from 25 per cent to 12 per cent over the same period.

Since the majority of mathematicians are engaged in teaching, it follows that education is the largest field of employment; two thirds of this group are employed in high schools and one third in the universities. Only 10 per cent are employed in government service, three quarters of this group being employed by the federal government. Private industry and business employ about 25 per cent of the mathematicians.

OUTLOOK

The present shortage of qualified mathematicians in all the technologically advanced countries is expected to persist for the foreseeable future. Demand will likely put more of a premium on mathematicians with advanced degrees than has been the case in the past.

ORGANIZATIONS

Canadian Mathematical Congress, *École Polytechnique,* 2500 Guyard Ave., Montreal, P.Q.

ADDITIONAL READING

Books

Courant, Richard and Herbert Robbins. *What is Mathematics*. Toronto. Oxford University Press. 1941.

Mathematical ideas and methods of interest to high school students.

Hogben, Lancelot. *Mathematics for the Million*. New York. W. W. Norton Co. Inc. 1943.

Sawyer, W. M. *Prelude to Mathematics*. Pelican Book series. Toronto. Penguin Books (Can.) 1955.

Of interest to advanced students.

VI

BIOLOGICAL SCIENCE[1]

Biological science, the study of living things, is tremendously important to mankind. Not only are we as living creatures concerned with understanding our own vital processes, but we depend on a host of living things for food, clothing, shelter and medicine. Greater knowledge and understanding of life's secrets help us improve our health and well-being, conserve and increase the fruitfulness of the earth, and cope with diseases and pests.

Life processes have always had a fascination for mankind, giving rise to many mystical and superstitious ideas. Time, and untiring study by many men and women, have brought order to our

[1] Read first, Section I, "Science in General".

Photo: Canada Department of Agriculture

Biologists are interested in learning more about all forms of life.

thinking and greatly increased our knowledge. Linneaus, a Swedish botanist of the 18th century, made a significant contribution by devising a method of identifying and classifying the many plants known to exist. The English biologist Charles Darwin developed a theory of evolution to account for the occurrence of the thousands of forms of life that abound on earth.

Although disease had been attributed to "small animalculae", it was not until the middle of the seventeenth century that Anton van Leeuwenhoek first saw bacteria with his newly developed microscope. Their relation to disease, however, was still poorly understood or unknown until Pasteur's work established that micro-organisms were responsible for disease, food spoilage and fermentation. The discovery of penicillin by Sir Alexander Fleming ushered in the era of antibiotics, and today this is one of the most active fields of biological research.

Mendel's discovery of the laws of heredity, followed by T. H. Morgan's theory of genes, focussed attention on that part of all living things that may hold the secret of life itself. Today the biochemist is actively investigating the nature and structure of desoxyribonucleic acid, the substance that forms the gene and carries the genetic code through successive generations.

BIOLOGICAL SCIENTISTS

In order to understand the work and occupational titles of biologists, one must know something of the science of biology and how it is organized.

The biologist is seldom just a *biologist*—he is usually a specialist in one or more of the many divisions and subdivisions of this broad science. Botany, zoology and microbiology are the main divisions of biology.

If he is engaged primarily in the study of plant life, the biologist is known as a *botanist*. As an expert on animal life, he is a *zoologist*. If he studies microscopic organisms he is a *microbiologist* or *bacteriologist*.

There is so much to be learned about each class and species of plants, animals and microscopic organisms that biologists may choose to concentrate their study on one particular class of species.

A botanist may specialize on the subject of grains (*cerealist*), algae (*phycologist*), or apples (*pomologist*), etc. A zoologist may specialize on insects (*entomologist*), mammals (*mammalogist*), birds (*ornithologist*), fish (*ichthyologist*), or reptiles (*herpetologist*), etc. A microbiologist may specialize on bacteria (*bacteriologist*), fungi (*mycologist*), cells (*cytologist*), or blood and serums (*haematologist* and *serologist*), etc.

Biologists may also specialize in one or more particular approaches to biological science:

morphology —study of the structure and changes in structure of living things, e.g., *plant morphologist*.

taxonomy —identification and classification of living things. Linneaus was a *taxonomist*.

genetics —a study of variation and heredity in species. Mendel, a pioneer *geneticist,* laid the cornerstone of our understanding of heredity.

physiology —study of function in living systems and isolated portions thereof.

ecology —study of living things in relation to their environment and each other. Ecology is of great importance in understanding the balance of nature, and how it is affected by man's activities.

pathology —study of the causes and effects of disease, e.g., *plant pathologist* or *animal pathologist*.

biochemistry —seeks to explain cellular reproduction, growth and metabolism in terms of chemistry. However, the biochemist must deal with very large molecules such as enzymes, proteins and nucleic acids, which are not always amenable to the procedures used in conventional chemistry. "Molecular biology" links the concepts of chemistry with those of biology; this is the field of the modern *biochemist*.

biophysics —is one of the newer branches of biological science. It attempts to explain cellular structures in physical terms. *Biophysicists* use such tools as electron microscopes and X ray diffraction equipment for studying living cells; they are also interested in the effects of ionizing radiation on biological material and related studies that apply the tools or principles of physics to biological material.

NATURE OF THE WORK

Biologists study and experiment with all forms of life and living processes. They control growing conditions, nutrition, breeding, make observations, and record data, usually with the help of technicians and laboratory assistants. They may work in laboratories, greenhouses, animal pens, or open fields. Some make extended field trips to study or collect plants or animals in their natural habitat—in the arctic, in arid regions, in the oceans or freshwater lakes and streams, on mountain tops—wherever living things are to be found. Today a great deal of laboratory work is required even in connection with the field studies mentioned above. Samples must be analysed and supplementary experiments conducted under controlled conditions if a full explanation of any phenomenon is to be obtained.

Some of the work may be slow and tedious. For example, the growth of living things must follow its natural course; experiments and studies in genetics and heredity, which are conducted on succeeding generations of plants and animals, may take years.

PREPARATION AND TRAINING

Education for a career in biology is usually taken at a university in the faculty of science. At present, 23 universities and colleges list first-degree courses in biology, others list botany, physiology, and zoology as separate degree courses. Agriculture and forestry courses are also heavily weighted with biology.

Approximately 65 per cent of the biologists have postgraduate degrees.

EMPLOYMENT OF BIOLOGISTS

Few biologists are self-employed; they usually work in industry, government or in the field of education. A recent study of graduates in biology revealed that less than 20 per cent were working in business and industry; about 45 per cent were in government service, and the rest were employed in the field of education.

Federal and provincial governments employ staffs of biologists to do research, give technical advice in formulating legislation, set standards of quality and purity, and help carry out inspection and control.

Canada's marine and freshwater fish resources, both commercial and sporting, are extensive and provide opportunities for research and management in federal and provincial government departments. The conservation of game and fur-bearing animals, migratory and resident birds, is a field of opportunity for wildlife biologists.

Preservation of the nation's health is a biological problem which concerns not only the medical profession, but also biologists specializing in food and drugs, parasitology, pest control, nutrition, etc. In military defence there are problems of biological warfare, nuclear radiation, and space medicine.

Biological products and processes play an important and sometimes basic role in some industries; for example, drug and pharmaceutical houses, private industrial laboratories, food and beverage processors, manufacturers of paper, textiles and other organic products.

OUTLOOK

Advances in biological science may not be as dramatic as those in other scientific fields, although they are often basic to human welfare. With continuing growth of government and university activity in biological research, in which 85 per cent of the biologists are employed, steady increases in demand are expected.

ORGANIZATIONS

Canadian Society of Plant Physiologists, Dept. of Botany, University of Toronto, Toronto, Ont.

Canadian Physiological Society, Defence Research Laboratories, P.O. Box 62, Station K, Toronto, Ont.

Canadian Phytopathological Society, Plant Research Institute, Central Experimental Farm, Ottawa, Can.

Canadian Biochemical Society, Ontario Agricultural College, Guelph, Ont.

Canadian Society of Microbiologists, Institute of Microbiology, 2900 Mont-Royal Blvd., Montreal, P.Q.

Entomological Society of Canada, K. W. Neatby Bldg., Central Experimental Farm, Ottawa, Can.

ADDITIONAL READING

Books

Bergier, Jacques. *Mystère de la vie*. Paris. Centurion. 1957.

Chambers, Robert W. and Alma S. Payne. *From Cell to Test Tube*. New York. Scribner. 1960.

Aims at a better understanding of the value and scope of biology and indicates some directions it may take in the future.

Reidman, Sarah R. *Charles Darwin*. New York. Holt & Co. 1959.

Vallery-Radot, Pierre. *Notre corps, cette merveille*. Paris. Éditions Bourrelier. 1945. 140 p.

Discusses the various organs and functions of the human body.

Bulletins and Pamphlets

Guidance Centre. *Biologist*. Monograph. Ontario College of Education. Toronto. 1960.

National Academy of Sciences—National Research Council. *Career Opportunities in Biology*. Rockefeller Institute for Medical Research, New York. 1956. 63 p.

Defines biology and outlines the various specializations and opportunities.

VII

SCIENCE IN AGRICULTURE[1]

Photo: Canada Department of Agriculture

Agricultural scientists examine a field crop of peas.

Agriculture is an industry concerned broadly with the cultivating, harvesting, storing and marketing of plants, and the breeding, raising and marketing of domestic animals. Scientists who work within the scope of agriculture are, by definition, *agricultural scientists,* although their fields of specialization may be in biology, chemistry, physics or geology. Agricultural scientists may also be concerned with economics, sociology, finance, marketing, production, and aspects of agricultural engineering such as irrigation, machinery, power, processing, and farm structures.

[1] Read first, Section I, "Science in General".

Provision for the orderly management of agriculture in Canada was made in the BNA Act of 1867, with responsibility shared by the federal government and the provinces. The federal government assumed the major role in agricultural research and in 1886 established a number of experimental farms under the direction of Dr. William Saunders.

Agriculture is one of Canada's most important primary industries, and contributes almost 6 per cent of the gross national product in raw materials. From her 300 thousand square miles of arable land comes food for the world's rapidly expanding population. Scientists in this industry, therefore, occupy an important place in the nation's scientific and technical manpower. Their work is to investigate how to increase productivity of farm lands, raise the quality of production, and reduce losses caused by pests and disease.

NATURE OF THE WORK

University-trained graduates in agricultural science may work in any of a number of broad fields of specialization. These include scientific research, inspection and control, teaching, extension and promotion services, technical sales, administration and, of course, farming.

Each field has its own set of functions, requiring special skills, personality characteristics and qualifications.

Scientific Research

About one fifth of the agriculturists are engaged in research. This activity covers research work in all the natural sciences as they apply to the utilization of plants and animals. It includes the development of new strains and varieties; their nutrition, diseases and pests; methods of engineering, and processing for human consumption. It also includes the fields of economic and social science relating to farm management, marketing, community development, and regional, national and international economic policy.

Qualifications

The usual qualifications for scientific research, outlined on p. 16, apply to this field.

A farm background is helpful for those whose research takes them into the field to deal with agricultural methods, crops and livestock. A bachelor's degree in science is essential, preferably in agricultural science. Those who wish to advance in research work should plan to do postgraduate studies leading to a master's degree or a doctorate.

Inspection and Control

This work includes grading and inspecting meats, dairy products, fruit and vegetables, eggs and poultry, seeds, wool and other agricultural products, the administration of laws covering the control of plant and animal diseases, and the quality of feeds, fertilizers and spray materials. Control of contagious diseases of animals is undertaken mainly by the federal Department of Agriculture.

Qualifications

A degree in veterinary science is needed for supervising the inspection of the health of animals and of grading meat. Most other fields of inspection and control are open to graduates in agricultural science. Some junior inspector classes require two or three years in college, or a good background of practical experience on the job. Inspectors dealing with farmers or meat-packing houses find a farm background very useful.

Extension and Promotion Services

Most provinces and some universities offer agricultural extension services to encourage farmers to use scientific farming methods and to take advantage of opportunities for farm improvement and rural community development.

Local extension workers are known as *agricultural representatives, district agriculturists* or, in Quebec, *agronomes*. Their work includes preparing printed material, speeches and other information, organizing meetings, campaigns, clubs, and generally promoting scientific agriculture in their areas. They are assisted by extension specialists from provincial departments of agriculture or agricultural colleges who are skilled in such fields as livestock, fruit, field crops, etc.

Qualifications

With few exceptions, a degree in agriculture, or its equivalent, is necessary for extension workers. They must be familiar with the agricultural possibilities and problems in their area in order to provide farmers with relevant scientific and economic information from universities and government agencies.

They must be able to get along with others and have an aptitude for making their ideas understood and accepted by farmers. Good health and ability to withstand extensive travel and long—often irregular—hours, are important. A farm background is almost indispensible.

Teaching

In addition to lecturing, this may include research. The teaching schedule may include instruction to students working toward a degree, a diploma, or a short-course certificate in some aspect of agriculture. About one quarter of the agriculture scientists are engaged in teaching as their main function.

Qualifications

Qualifications for teaching agriculture vary, and may range from a teacher's certificate in secondary schools to a degree in science or agriculture for teaching in a college or university. Teaching in the latter usually requires a postgraduate degree.

Technical Sales, Service, Marketing and Purchasing

The economic as well as the scientific and technical aspects of agriculture are reflected in this kind of work. Private businesses and government departments catering to the needs of farmers are the main employers.

Qualifications

This work requires persons with a good combination of technical knowledge, business sense, and the ability to deal with people, in addition to a familiarity with farm problems. Investigation shows that a bachelor's degree in science or agriculture is generally sufficient background for work of this nature, although postgraduate degrees may be required for some technical positions.

Farming

Many graduates in agriculture are operating farms, and use their specialized training in applying scientific methods to farming operations. The variety of functions involved in organizing and operating a farm need hardly be detailed here.

Qualifications

Since farming is a way of life as well as a business and scientific enterprise, personal attitudes and interests are important in determining success. It is not unuual for a farmer's son, who has had the opportunity to evaluate his liking for farming, to prepare himself by formal scientific training eventually to take over management of the farm, or to find employment elsewhere as a farm manager.

Administration

Administration consists in organizing, planning and directing the work of a scientific section or division, handling personnel, and dealing with the day-to-day problems that arise in any organization. Although administration is not in itself a scientific activity, a substantial number of scientists find themselves involved in administrative duties, sometimes to the exclusion of work in science. In many cases this has been the only avenue of advancement for a scientist. However, as pointed out on p. 24, increasing attention is now being paid to creating ladders of advancement which depend on scientific ability alone.

Qualifications

High technical ability is not usually required for administrative work; the main prerequisites are leadership, ability to plan and organize work for groups of people, and skill in human relations. These are rare and valuable attributes, sometimes acquired only after long experience, which may account for the fact that administrative positions are usually well paid, and occupied mainly by senior personnel.

PREPARATION AND TRAINING

Practice of agricultural science on a professional level requires a four-year course at a university faculty of agriculture, leading to a bachelor's degree. Surveys show, however, that small numbers

of graduates in biology, chemistry, forestry or general science also find careers in the agricultural field. Conversely, a substantial number of graduates in agriculture find employment in fields outside agriculture—in bacteriology, biology, chemistry, geography, mathematics, physics, physiology and biochemistry. It is evident that degree courses in agriculture are broad enough in scope to prepare graduates for a wide variety of scientific careers.

Practical experience in agriculture is required by most universities before a degree is granted. Students who come from urban areas may have to find summer employment in agriculture in order to satisfy requirements. The Federal Department of Agriculture employs many student assistants for the summer months.

EMPLOYMENT OF AGRICULTURISTS

Since governments are vitally interested in agricultural progress, it is not surprising that the federal and provincial departments of agriculture employ nearly 60 per cent of the scientists in this field. About 30 per cent are employed by industrial and commercial firms concerned with selling goods to farmers, financing their enterprises, processing, marketing or transporting their products, or publishing periodicals of interest to farmers.

Educational institutions employ about ten per cent of the agriculturists, the majority of whom work in universities and colleges.

OUTLOOK

Continued and steady growth in demand for agricultural scientists is expected through the years ahead. Need for the scientific approach in almost all areas of agriculture has become well established over the past half century. Such trends as the movement off the land, rising labour costs and strengthening world competition, have led to increasing farm mechanization, better land usage, introduction of new products and improved methods of operation. These trends can be expected to continue, with even greater reliance in future being placed on the discoveries of science.

ORGANIZATIONS

Agricultural Institute of Canada, 176 Gloucester St., Ottawa 4, Canada.

La Corporation des Agronomes, Room 902, 10 St. James St. W., Montreal, P.Q.

ADDITIONAL READING

Agricultural Institute of Canada. *Careers in Agriculture* (*Carrières agronomiques*). Ottawa. 24 p.

Outlines the wide range of careers open to graduates in agriculture.

Agricultural Institute of Canada. *Careers in Agriculture.* (Reprint from *Agricultural Institute Review,* March-April 1957). 68 p.

Each section is written by a person engaged in a particular branch of agriculture.

Department of Agriculture. *Farming in Canada* (*Agriculture canadienne*). Information Division, Ottawa. 1960. 80 p.

Briefly outlines agricultural districts, methods of farming, crops, farm population and services available to farmers.

VIII

FOREST SCIENCE[1]

Forest science is concerned with the establishment, protection, and care of forests; the measurement of trees and timber stands; surveying and mapping of timber stands; and the cutting, extraction, measurement, and use of wood.

Forests are one of Canada's most valuable renewable resources. Total forested land amounts to more than 1,700,000 square miles, of which nearly 60 per cent contains merchantable timber. The federal government is responsible for administering all forests

[1] Read first, Section I, "Science in General".

Photo: NFB

Tree physiologist uses a portable scintillation counter to measure radiation at the top of a tree. Flow of nutrients through a tree is determined by introducing a radioactive isotope into the food stream. Readings of radioactivity, taken at various levels, indicate the rate at which this food passes through the tree.

in national parks and some experimental forest stations within provincial boundaries, and the relatively unknown forests of the Yukon and Northwest Territories. Provincial governments administer publicly owned forests within their boundaries. They protect the forests from fire, look after leasing of timber lands, and control cutting operations. Logging is carried out by private operators.

Canada's forest research started in 1917 when the federal Forestry Branch was authorized to conduct silvicultural experiments at Petawawa Military Reserve in Ontario. The first research forester was appointed in 1918. Now, with headquarters in Ottawa, and district offices or experimental centres located in all provinces, research is carried forward in co-operation with provincial governments and the forestry industry.

Creation of a federal Department of Forestry in 1960 brought together federal responsibility for all aspects of forest management and research formerly shared by the Forestry Branch of the Department of Northern Affairs and National Resources, and the Department of Agriculture.

NATURE OF THE WORK

To the forester, a forest site is much more than a collection of trees of economic importance to be exploited for immediate profit. It is a complex biological system, consisting mainly of trees and other minor flora, which is affected in varying degrees by terrain, soils and climate, plant diseases, insects and parasites, wildlife, fires, and logging operations. Broadly speaking, it is the function of Canada's foresters to protect and manage the forests in a way that yields the most benefit to the Canadian people both now and in the future.

Forestry is similar to agriculture in that it is based to an increasing extent on scientific research while retaining its practical economic and engineering aspects.

Science aspects of forestry lie in research leading to a better understanding of the factors affecting the growth and regeneration of forests. This includes silviculture, forest ecology, forest entomology and forest pathology, all of which derive from biological science (see Section VI) with special reference to forest

problems. Chemistry and physics also contribute to the total picture of forestry research in studies on soil analysis, insecticides and fungicides, weather and climate conditions, and the development and testing of fire fighting methods and equipment. Research is the main function of about 20 per cent of Canada's foresters.

Operational or engineering aspects of forestry are illustrated by the harvesting of the forest crop. In this work, foresters are engaged in surveying and mapping timber tracts, calculating the volume of timber in a tract and the cost of extracting it. They plan and execute logging operations, including the location and construction of extraction roads, improvement of streams for driving logs, construction of dams and bridges, and the supervision of logging camps and woods workers. About 20 per cent of the foresters are engaged in the production aspect of forestry; 10 per cent are in field exploration, and a small number are in marketing.

Separation of research and engineering aspects of forestry is not always clear cut. Individual foresters may find themselves involved in a variety of activities as *generalists;* others may become highly specialized in research. Nearly 35 per cent of the foresters—the largest proportion of those in any of the science fields—are engaged chiefly in executive, management or supervisory work. On the other hand, less than 5 per cent—the smallest proportion of those in any science field—are engaged in teaching as their main function.

EMPLOYMENT OF FORESTERS

More than half of Canada's foresters are employed by industrial concerns, particularly pulp and paper and to a lesser extent, lumber companies. They are mainly engaged in harvesting and marketing the forest crop or in administration. Some are employed by secondary industries using or making forest products.

With the exception of a small number of foresters employed in the educational field, the remainder are employed in government service, about two thirds of whom are with provincial governments. Many of the foresters employed by provincial governments are engaged in fire protection; others are engaged in the disposal of timber rights on provincial Crown lands and, after these rights

have been granted, in carrying out inspections to ensure that the agreement with the private company has been observed. A considerable number of foresters are engaged in reforestation and, others in a variety of duties related to forestry in general.

The federal Department of Forestry, in co-operation with the provincial governments and universities, is conducting extensive research in silviculture, forest fire protection, forest management, forest entomology and pathology, and forest products.

PERSONAL QUALITIES NEEDED

Forest science will appeal to those who love the outdoors and have a deep appreciation of the value and beauty of forests and the creatures that live in them. The wide variety of activities related to forestry, from the practical economics of forest management and problems of harvesting, to the enigmas of forest research, make forest science attractive to people of widely differing interests and abilities.

Invariably, and particularly at the beginning of a graduate's career, much of the work will be outdoors, with all the attendant discomforts of inclement weather, insects, dangers and isolation, as well as the healthy stimulation and satisfaction that come with living in the woods. Forestry work, much more than other science fields, demands a robust physique and good eyesight, resourcefulness, ingenuity, and ability to take care of oneself in the woods.

Frequent field trips take foresters away from home, and the increasing use of specially equipped trailers is making it possible to do more and more laboratory work while in the forest. Such field trips interfere with regular home life and call for some sacrifice on the part of the forester and his family. However, the use of trailers is also making it possible for the forester's family to accompany him on field trips.

Young people can test their interest in and ability for forestry work and life in the outdoors through activity in scouting, camping, field naturalist and 4-H clubs. Further information may be obtained by speaking to local forestry officials, and by visiting an experimental forestry station or logging establishment.

PREPARATION AND TRAINING

Most foresters enter the profession by graduating from a university faculty of forestry. The course leading to a bachelor's degree is usually four years and provides broad training in various aspects of forestry: dendrology, forest protection, forest soils, silvics, silviculture, wood structure and technology, forest mensuration, logging, forest utilization, and a forest management project. Related subjects are taken: physics, zoology, forest entomology, botany, chemistry, surveying, photogrammetry, mathematics and statistical methods, and also literature and composition, economics, history, and business administration. As a rule, students can select optional subjects for particular study in latter years of their course.

Universities offering degree courses in forestry are: University of British Columbia, Laval University, University of New Brunswick and University of Toronto. The University of British Columbia offers graduate studies leading to a doctorate; the other three offer courses leading to a master's degree. Practical experience in the field is necessary, as a rule, to qualify for a degree. Registration with the provincial forestry association is necessary before a person can practise forestry in British Columbia, Ontario, Quebec and New Brunswick.

A survey of scientists and technical personnel in forestry in 1960 indicated that nearly 80 per cent had bachelor degrees and nearly 20 per cent had postgraduate degrees.

OUTLOOK

Our forests, long treated as an expendable asset, are now considered a precious renewable resource. Increasing emphasis on scientific management, conservation and utilization, as seen in the formation of a federal Department of Forestry, should lead to a greater demand for forest scientists in the years to come. The number of positions in the federal government, for example, is expected to double in the next ten years.

ORGANIZATIONS

Canadian Institute of Forestry, c/o Macdonald College, Ste. Anne de Bellevue, Que.

Corporation des Ingénieurs forestiers de la province de Québec, 895 rue d'Aiguillon, Québec, Que.

Ontario Professional Foresters Association,
357 Botsford St., Newmarket, Ontario

Association of British Columbia Foresters,
c/o Faculty of Forestry, University of British Columbia,
Vancouver, B.C.

Association of Registered Professional Foresters of New Brunswick,
P.O. Box 231, Fredericton, N.B.

ADDITIONAL READING

Bulletins and Pamphlets

Canadian Institute of Forestry. *The Canadian Forester in his Job*. Toronto. 1958.

A collection of talks by professional foresters delivered at a meeting of the Vocational Guidance Directors of Secondary Schools of Metropolitan Toronto.

Guidance Centre. *Forester*. Monograph. Ontario College of Education. Toronto. 1961.

Department of Forestry. Motor Building, Ottawa. *Canada's Forests, 1951-1955*. 1957.

LOCAL INFORMATION

LOCAL INFORMATION

CANADIAN OCCUPATIONS FILMSTRIPS

The Department of Labour has prepared, to date, the following occupational filmstrips in collaboration with the National Film Board. A manual has been prepared as an accompaniment to each filmstrip. These may be purchased from the National Film Board, Box 6100, Montreal, or from any one of its regional offices. Prices in Canada: Black and white prints $2.00; colour, $4.00.

Plumber, Pipefitter and Steamfitter

Careers in Engineering (revised in colour)

The Social Worker

Technical Occupations in Radio and Electronics

Bricklayer and Stone-Mason

Printing Trades

*Careers in Natural Science (revised in colour)

Careers in Home Economics

Motor Vehicle Mechanic

Mining Occupations

Draughtsman

Careers in Construction

Machine Shop Occupations

Sheet-Metal Worker

Careers in Meteorology

Medical Laboratory Technologist (in colour)

Teacher (in colour)

Office Occupations (in colour)

*A visual presentation of the essential facts in this monograph.

CAREERS IN NATURAL SCIENCE

Monograph No. 21

CANADIAN OCCUPATIONS

★

HOSPITAL WORKERS

(Other than Professional)

★

MONOGRAPH 36

DEPARTMENT OF LABOUR, OTTAWA

CANADIAN OCCUPATIONS

★

HOSPITAL WORKERS

(Other than Professional)

MONOGRAPH 36

HON. MILTON F. GREGG, V.C., MINISTER
A. H. BROWN, DEPUTY MINISTER

DEPARTMENT OF LABOUR, OTTAWA

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FOREWORD

During recent years there has been a steadily increasing demand for up-to-date information on occupations.

This demand comes from youth faced with the need of choosing an occupation and of selecting the type of training required; from parents, teachers and other counsellors; from workers shifting to other occupations; from employment service officers; from directors of personnel and union officials, and from other quarters.

This series of monographs and an accompanying series of pamphlets, the latter containing similar information in a condensed form, are attempts to meet this demand.

These publications represent an expansion of an earlier series issued by the Department of Veterans Affairs to assist members of the armed forces returning to civilian life following the end of the war. These current series, designed for general use, cover a wide range of occupations, including professions. They indicate, among other things, the nature of the occupation or group of occupations, entrance and training requirements, working conditions and opportunities in each.

This monograph, as was the case in those which preceded it, was prepared by the research staff in the Occupational Analysis Section. In the case of this monograph valuable assistance, by way of providing information and checking basic material, was given by officials of the Departments of National Health and Welfare and Veterans Affairs, the Canadian Nurses' Association and the Salvation Army. The contribution of these officials, together with the assistance of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour and the Dominion Bureau of Statistics is gratefully acknowledged.

DIRECTOR,
Economics and Research Branch,
Department of Labour.

June, 1954.

HOSPITAL WORKERS
(Other than Professional)

Photo: N.F.B.

An X-ray Technician at work.

HISTORY AND IMPORTANCE

Hospitals for the care and treatment of the sick have played a very important role in the evolution of society. The rulers of India, Persia and Arabia maintained such institutions in very early times. Healing was practised in the temples of ancient Egypt, Greece and Rome. In 300 B.C., according to tradition, the "House of Sorrow", was founded in Ireland for the care of the sick and wounded. With the spread of Christianity, hospitals multiplied rapidly, and soon monasteries had some provision for the care of patients. The first recorded hospital in England was one founded in 900 A.D. by the Archbishop of Canterbury; in Canada, the Hotel Dieu du Precieux Sang of Quebec City was established in 1639.

In the course of time hospitals began to spring up in the larger centres, and then in smaller communities. Soon it became evident that the church groups, which had sponsored their organization, were unable to keep pace with the demand for such services. Public hospitals having no church connection, and administered by a board of interested citizens, became increasingly numerous. The next step was the development of hospitals designed for special types of illness, sometimes operating as an independent unit and sometimes as one of a group.

In early times, the persons engaged in caring for the sick — the doctors and nurses — were usually connected with the church. As the demand for treatment facilities increased, larger institutions, including non-sectarian hospitals, came into being and thus the demand for lay workers to staff these institutions increased. Legislation on social and sanitary matters added to the need.

We now have engaged in hospital work definite occupational groups, which may be roughly divided into three main categories: a professional class of doctors, registered nurses (and nurses-in-training), dietitians, pharmacists, occupational and physical therapists, some highly trained technicians, medical and psychiatric social workers and medical librarians; a semi-professional class — workers who have a certain technical training in laboratories or in the operation of equipment (such as X-ray machines); and a non-professional class — the auxiliary nursing, housekeeping, kitchen and clerical staffs, and tradesmen. In addition to these three classes of workers some large hospitals

engage non-medical superintendents in an administrative capacity.

It is the semi-professional and non-professional workers who will be considered in this monograph. Special emphasis will be laid on the requirements and training of certain auxiliary nursing groups that are being used extensively in many hospitals to augment the services of the professional staff.

Auxiliary nursing workers have been used to some extent in hospitals for many years, but it was not until the First World War, and more particularly the Second World War, when nurses and doctors were scarce, that these workers became a recognized part of the hospital nursing team. Routine duties, not requiring professional care, were assumed by them after they had received appropriate training.

FIELD OF WORK

The field of work is the hospital, an institution where people who are physically or mentally ill are brought for treatment and care, either as in-patients or out-patients. Hospitals are not all alike. They have certain basic similarities, since their common aim is the care of the sick and injured, but there is considerable variation in staff requirements and conditions of work because of the kind of patients admitted and, to a lesser degree, the ownership or control of the hospital. This diversity, added to that of size, makes it impossible to apply specific details to all cases.

General Hospitals — This is the familiar hospital that is found in most communities, in which patients requiring many types of treatment are cared for. Institutions of this kind may be small, in which case all patients will be cared for by one staff, or they may be highly developed, having "wings" or "floors", each with its own staff of workers and equipment, set aside for patients having a particular illness.

Special Hospitals — In many cases it is found advisable, because of the particular nature of the illness, the number of such cases to be cared for, the special treatment the patients require and the expensive equipment necessary, to establish hospitals which limit their services to a single field. Special hospitals are found chiefly in or near large centres, though sanatoria are an exception in this respect.

Special hospitals include *mental hospitals*, where patients having mental illnesses are treated and cared for; *tuberculosis sanatoria; women's hospitals* for gynaecological and maternity patients; *children's hospitals* for the care of children only; *hospitals for chronic illness; convalescent hospitals* for the treatment and care of patients recovering from an illness or injury. Also there are in operation a few small hospitals or "clinics" for the treatment of a particular illness. *Isolation hospitals* for the treatment of contagious and infectious diseases are sometimes separate institutions.

General and special hospitals may be either government or non-government owned and controlled.

Government-owned-and-operated hospitals include those of the Federal Government Department of National Defence, (Navy, Army and Air Force Hospitals), Department of Veterans Affairs, (Veterans' Hospitals), and Department of National Health and Welfare, (Indian Health Services, Marine and Quarantine Hospitals); and Provincial, County and Municipal hospitals. Mental and tuberculosis hospitals are largely provincial institutions.

Non-government hospitals are those operated by religious organizations, communities, fraternal orders, and the Red Cross, as well as private hospitals operated on either a profit or a non-profit basis.

DUTIES

Semi-professional workers, such as pathological, blood bank and X-ray technicians, work under professional direction in their own fields.

The non-professional personnel of a modern hospital may be divided into five teams of workers, each with its specific sphere of work.

Working under the close supervision of the registered nurses is a group of auxiliary nursing workers, who assist in the care of the patients. The trained nursing assistant ("nurses' aide" or "practical nurse") is a comparatively new addition to hospital personnel, and his or her duties and titles in the various hospitals and provinces have not yet been uniformly established. In mental hospitals there is the psychiatric aide and attendant.

These workers carry out a multitude of simple tasks, making life more pleasant for the patient and releasing the trained nurse for more responsible duties. The trained orderly holds an equally important position on the nursing team, and is responsible, among other things, for much of the personal care of male patients.

The general duties of the other four groups parallel those done by similar personnel in a large hotel: the *kitchen staff* are employed in preparing food for the patients, including special diets, and for the staff; *housekeeping staff*, comprising women and men, maintain a high standard of cleanliness on the premises, and do the mending and laundry; *tradesmen and allied workers* include maintenance tradesmen and other workers such as truck and ambulance drivers, operators of mechanical equipment and grounds keepers; the *clerical staff* does work similar to that found in a general office.

Some appreciation of what is generally required in a hospital may be gathered from the list of main occupations and duties which follows. The size and type of the institution will make for variations in duties.

SEMI-PROFESSIONAL GROUP

A *Blood Bank Technician* prepares donors, extracts the blood, types and stores it, and maintains records.

A *Pathological Technician* performs mechanical work in a laboratory while working under close supervision: detects the presence or absence of bacteria by making tests, using such instruments as microscopes and micrometers.

The *X-ray Technician* assists the radiologist by operating X-ray equipment: prepares patients for treatment, manipulates switches to regulate time and intensity of exposure, and develops films; many specialize in X-rays of certain parts of the body, such as the chest, abdomen, etc.

NON-PROFESSIONAL GROUP

AUXILIARY NURSING GROUP

The trained *Nursing Assistant* ("nurses' aide" or "practical nurse") who has taken a course at one of the approved schools

of nursing, carries out simple nursing procedures under the supervision of a registered nurse; such as bedmaking, bathing of patients, making a patient comfortable, taking of temperatures and minor treatments.

Increasingly, the nursing assistant is looked upon as an important and indispensable member of the Nursing Team and her work offers many opportunities for personal satisfaction.

The *Psychiatric Aide* and the *Psychiatric Attendant* ("practical nurse with psychiatric training") also carry out nursing duties under the supervision of a registered nurse but in a mental hospital. Their duties, in most cases, will be somewhat different from those of the general nursing assistant and will include such tasks as assisting a number of patients in their daily routine and reporting to the supervisor any change in their behavior.

The *Ward Aide* ("ward maid") may also, on occasion, assist in simple nursing procedures, such as dressing and feeding of patients, but the main part of her duties is likely to be in the housekeeping area — cleaning of patients' units (beds, lockers, tables), cleaning of equipment and the care of flowers.

The *Orderly* ("nursing attendant") assists the nursing staff by performing various heavy duties: lifts patients to and from beds, wheels them to and from the operating room, moves equipment and supplies; many carry trays, make beds, do cleaning and odd jobs and attend to the personal care of male patients. Orderlies who have more than the minimum training required may, in addition, give simple treatments under the supervision of a nurse, or may be attached to a specific department, such as an operating room or pathological department, where they perform special duties.

A *Ward Clerk* performs certain clerical duties in the ward office under the direction of the head nurse; answers the telephone, directs visitors, keeps records, writes discharge forms, takes messages, and does other clerical duties.

KITCHEN STAFF

The feeding of patients and staff, usually under direction of a dietitian, requires the following workers: chef, cooks, butchers, vegetable preparers, dishwashers, waiters and kitchenmaids. Their duties are indicated by their titles.

Photo: N.F.B.

Mealtime.

HOUSEKEEPING STAFF

In charge of this group is a *housekeeper*, who sets and maintains standards of cleanliness and efficiency, and assigns duties, gives out supplies and equipment, and has charge of linens. Her subordinates include: porters, wallwashers, window-cleaners, charwomen, maids, linen-room women (or men), seamstresses, laundrymen and laundresses, and stock clerks.

TRADESMEN AND ALLIED WORKERS

This group includes such skilled men as gardeners or grounds keepers, stationary engineers, carpenters, plumbers, electricians and painters.

Elevator operators (passenger or freight), truck drivers, watchmen and labourers are also employed.

CLERICAL STAFF

Depending on the size of the institution, there may be found: office manager, personnel clerk, accountants, bookkeepers, stenographers, office machine operators, switchboard operators, and general clerks. Some of these will need to acquire a knowledge of hospital routine and of medical terminology, particularly so in the case of secretaries and clerks assigned to doctors or to laboratory work.

QUALIFICATIONS

Within the field of semi-professional and non-professional workers in hospitals, there is a place for both men and women who can meet the standards of a particular institution. Technicians, nursing assistants, psychiatric aides and attendants, and orderlies must be, in most cases, at least 18 years of age; other workers may be younger in accordance with the minimum age regulations of the various provinces.

All workers must submit to a medical examination and show a clean bill of health. Those who work with foods must have check-ups at regular intervals.

In most hospitals the minimum educational standard for technicians is Grade 12 or 13, for nursing assistants, psychiatric aides and attendants, and orderlies, Grade 8 to 10. Tradesmen,

such as cooks and maintenance tradesmen, are expected to have completed their training prior to employment in a hospital. There is no educational standard set for those doing cleaning or other tasks where the worker has little responsibility, or needs to possess only special skills.

Hospital routine and atmosphere demand that all workers, and particularly those who come into contact with the patients or visitors, perform their duties in a sure and efficient manner, and that they exercise good judgment, be courteous, pleasant and of neat appearance. A good memory is a definite asset.

TRAINING

Workers who have no contact with patients seldom undergo any training other than that in their own duties to fit them for their work, although in some hospitals first aid is given or a short course planned to help them become adjusted to their work.

There is no *uniform* course of training for the semi-professional or non-professional staffs, as it has been left to the various hospitals to develop their own programs to fit their individual needs. Many hospitals have done this in the past and are continuing to do so, particularly hospitals or groups of hospitals operated by the various religious orders doing general or sanatoria nursing, and by mental and tuberculosis hospitals.

As an indication of what training courses are available, and the type of training given, certain of the better-known programs are outlined:

Pathology and Blood Bank Technicians

These are relatively new fields of work; in many cases such employees are used as assistants only, while in others, they may be responsible for the complete task. Both occupations are made up largely of women workers.

While the practice is not universal, some hospitals are now giving a one-year course, at the completion of which successful students are granted a certificate. Those wishing to enter a course must be at least 18 years of age, have a Grade 12 standing and be interested in exacting work; must be sympathetic and reassuring, as their attitude will have an effect on the patient and on public relations.

The training that a technician receives in a hospital is, for the most part, on the job. This is complemented by lectures on related subjects such as anatomy, physiology and psychology, etc., and also on the equipment and methods used.

X-ray Technician

This occupation is also a relatively new one, and the majority of technicians are women. Some enter the occupation after one or two years of university training, or through special courses after obtaining a nursing diploma. A substantial number begin in a hospital or clinic, where they learn by working in an X-ray department and by taking lectures in related subjects. The applicant should be at least 18 years of age and have completed Grade 12.

Students who enter a hospital or clinic, where the training program has been approved by the Canadian Association of Radiologists and the Canadian Society of Radiological Technicians and is conducted under the direction of a qualified radiologist, are permitted after two years training, to write their examination for a certificate and to use the title of Registered Technician (RT).

Training has been approved at the following hospitals and related institutions in Canada.

Nova Scotia

- Halifax — The Halifax Infirmary
- Antigonish — St. Martha's Hospital

New Brunswick

- Saint John — St. Joseph's Hospital

Quebec

- Montreal — The Royal Victoria Hospital, Montreal General Hospital, and a number of other hospitals that are participating in a well organized training program.

Ontario

- Chatham — General Hospital
- Cornwall — Hotel Dieu Hospital
- Hamilton — General Hospital
- Kingston — General Hospital
- Ottawa — General Hospital
- Toronto — Toronto General Hospital
- — Sunnybrook Hospital

Manitoba

- St. Boniface — St. Boniface Hospital
- Winnipeg — The General Hospital

Photo: N.F.B.

Pathologist and Technician examine diseased tissue.

Saskatchewan

Moose Jaw — Moose Jaw General Hospital
Regina — Regina General Hospital
— The Grey Nuns' Hospital
Saskatoon — Saskatoon City Hospital
— St. Paul's Hospital

Alberta

Calgary — The General Hospital
— The Colonel Belcher Hospital
— The Radium and X-ray Institute
Edmonton — University of Alberta Hospital and Clinic

British Columbia

Vancouver — The General Hospital
— St. Paul's Hospital
— Shaughnessy Hospital
Victoria — St. Joseph's Hospital
— Royal Jubilee Hospital

For additional information concerning other possible centres of training, enquiries should be made of the secretary of the Member-Society of the Canadian Society of Radiological Technicians in the appropriate province.

Nova Scotia Society of Radiographers
New Brunswick Society of X-ray Technicians
Quebec Society of X-ray Technicians
Ontario Society of Radiographers
Manitoba Society of X-ray Technicians
Saskatchewan Society of X-ray Technicians
Alberta Society of Radiological Technicians
British Columbia Society of X-ray Technicians

Nursing Assistant, (Nurses' Aide, Practical Nurse)

The formal training of a nursing assistant, nurses' aide, or practical nurse, is a recent development. Many untrained women have performed great service in the home, being of assistance in the sick room and in caring for the immediate needs of the other members of the family. The nursing assistant can now perform this necessary task, better equipped for the job through training, or make a permanent place for herself on the hospital nursing team.

While most nursing assistants are girls a few hospitals are now training male nursing assistants. Their courses of study are similar.

In most cases, the person applying for training is required to have a minimum educational standing of from Grade 8 to 10. (If a girl has the necessary educational qualifications, most interviewers will urge that she take the full nursing course leading to the standing of registered nurse, as the time spent in becoming a nursing assistant is nowhere in Canada officially accepted for credit on the more advanced course).

The training given in the various hospitals is in proportion to the responsibility placed upon the worker. In the majority of cases, the nursing assistants' course is from 9 to 18 months duration; approximately one-third of the time is spent on theory and the remainder in practical work. The theoretical instruction runs concurrently with the practical work in some training schools; in others it precedes the practical work, with further lectures during the latter part of the training program.

A typical program will provide instruction in: the human body and its functions, elementary nursing, home and hospital housekeeping, food selection, cooking and sewing, health and personal hygiene, personal adjustments and human relations, first aid and bandaging, care of mother and newborn baby, measurements and solutions.

As a rule, in hospitals where the training of nursing assistants is undertaken, some arrangement is made for the trainee to take a part of the course in a tuberculosis hospital, so as to have a broader experience.

By way of illustration two well-defined programs are outlined below; one sponsored by various provincial groups and the Federal Government, and one given in the Salvation Army hospitals in Vancouver, Halifax, Toronto, Montreal and Ottawa.

i) Provincial Nursing Plans.

In eight provinces, eighteen schools have been established to conduct courses and to arrange for practical training in hospitals under the sponsorship of provincial nursing organizations, hospitals, and the Federal and Provincial Governments. A well-rounded program, conforming to the individual needs and laws of the province, is presented and a certificate is awarded successful trainees.

For convenience and brevity, the various requirements and outstanding features of the programs are presented in the accompanying table:

TRAINING AS GIVEN UNDER PROVINCIAL NON-PROFESSIONAL NURSING PLANS: AGE, REQUIREMENTS, DURATION OF COURSES, ETC.

	Age	Min. Education	Duration of Course	Title
New Brunswick		Grade		
Moncton (1)	18	8	9 mos. 3 mos. school 6 mos. hospital	Certified Practical Nurse
Quebec				
L'école de Ste. Geneviève Montreal (French)	18	8	16 mos. 3 mos. school 9 mos. hospital 4 mos.-affiliated hospitals	Infirmières-Auxiliaires (Diploma granted)
Ontario				
Toronto, Hamilton, Sudbury, Ottawa, Fort William	17–45	8	10 mos. 4 mos. school 6 mos. hospital	Certified Nursing Assistant (2)
Brockville	17	8	10 mos. 3 mos. school 7 mos. hospital	Certified Nursing Assistant (2)
Picton	18–40	9	10 mos. 3 mos. school 7 mos. hospital	Certified Nursing Assistant (2)
Ottawa (Bilingual)	17–45	8	10 mos. 3 mos. school 7 mos. hospital	Certified Nursing Assistant (2)
Manitoba				
Winnipeg, St. Boniface	18–55	8	1 year 3 mos. school 9 mos. hospital	Licensed Practical Nurse (3)
Saskatchewan				
Saskatoon	18–35	8	9 mos. 14 weeks school 22 weeks hospital	Nursing Assistant
Alberta				
Calgary	17–40	9	40 weeks 20 weeks school 20 weeks hospital	Certified Nursing Aide
British Columbia				
Vancouver	18–45	10	1 year 4 mos. school 8 mos. hospital	Licensed Practical Nurse
Veteran Hospitals				
Toronto, Halifax, Montreal	18–40	9	10 mos. 1st part school 2nd part hospital	Certified Nursing Assistant

(1) The Moncton training centre accepts students from Nova Scotia.

(2) The trainee is entitled to register as a *certified* nursing assistant with the Department of Health. This is her proof of training.

(3) Licensing is obligatory by provincial law in Manitoba to safeguard the status of the qualified practical nurse. When the student has successfully completed her course, she makes application for a license to practise to the Licensing Board, Department of Health and Public Welfare. If the student is under 21 years of age, she must have a *special license* to practise.

EXPENSES AND REMUNERATION DURING TRAINING† UNDER PROVINCIAL TRAINING PLANS FOR NON-PROFESSIONAL NURSES

Province	Fees	Pay		Room and Board Provided	Uniforms
		School	Hospital		
New Brunswick*	Nil	\$ 6–\$21 per Wk.	\$15–\$25 per Mo.	During hospital period	\$35 (charge)
Quebec					
Montreal (Fr.)	Nil	\$22.50 per Mo.		Yes	\$20 (charge)
Ontario					
Toronto, Hamilton, Sudbury, Ottawa, Fort William*	Nil	\$60 per Mo.		No	Provided
Brockville			\$10–\$15 per Mo.	Yes	Provided
Picton	Nil	Nil	\$20 per Mo.	Yes	Provided
Ottawa (Bilingual)	Nil	Nil	\$10–\$15	Yes	Provided
Manitoba					
Winnipeg, St. Boniface	Nil	Nil	\$20 per Mo. per Mo.	During hospital period	\$40 (charge)
Saskatchewan*	Nil	\$1.15–\$3.00 per Day		Noon meal at hospital	Provided
Alberta*	Nil	\$10.50–\$19.50 per Wk.		During hospital period	Provided
British Columbia	\$28	\$14 per Wk.	\$20 per Wk.	No	Provided
Veteran hospitals	\$40	\$70 per Mo.		No	\$30 (charge)

† Subject to change from year to year.

* Transportation paid from home to training centre.

APPLICATION FOR TRAINING OR REQUESTS FOR FURTHER INFORMATION SHOULD BE MADE TO:

Co-ordinator,
School for Practical Nurses,
Vancouver Vocational Institute,
Victory Square, Vancouver, B.C.

Registrar-Consultant,
Training School for Certified Nursing Aides,
1315-16th Ave., N.W.,
Calgary, Alta.

Regional Director,
Canadian Vocational Training,
Department of Education,
Regina, Sask.

Registrar-Consultant for Licensed Practical Nurses,
320 Sherbrooke St.,
Winnipeg, Manitoba.

Director, St. Boniface School for Licensed Practical Nurses,
171 Despins Street,
St. Boniface, Man.

Director, Nursing Branch,
Ontario Department of Health,
Parliament Buildings,
Toronto, Ont.

Certified Nursing Assistant Training School (Bilingual)
St. Vincent Hospital,
Ottawa, Ont.

Directrice,
L'école St-Geneviève,
Hôpital St-Joseph,
Bordeaux, Montréal (Québec).

Director of Canadian Vocational Training,
New Brunswick, or
Nova Scotia.

Nursing Consultant,
Department of Veterans Affairs,
Sunnybrook Hospital,
Toronto, Ont.

ii) Salvation Army Hospitals

The five hospitals are primarily for maternity cases, and thus much of the training is centred about this phase of nursing. The course of training, which is of 18 months' duration, is one in general nursing excluding surgery. The student is taught nursing theory and special treatment, with emphasis on the type of nursing encountered in maternity work.

The trainee must be at least 18 years of age, and have completed two years of high school. During the 18-month training period she lives in residence, works an 8-hour shift with one day off each week and four hours off on Sunday, and is entitled to three weeks' vacation. At the end of the course, the graduate receives from the school a diploma that is recognized by many of the small hospitals of the country.

After the three-month probationary period the trainee receives a small allowance.

New classes begin in the spring and fall. Applications for information regarding training should be made to the Director

of Nursing Services at any one of the five Salvation Army hospitals previously listed in this monograph.

Psychiatric Aide and Psychiatric Attendant

For many years the Canadian mental hospitals were operated by registered nurses who received all or most of their training in general hospitals, and a staff of attendants who received training in their work so as to supply good custodial care for the patients. The shortage of trained nursing personnel in all hospitals, and particularly in mental hospitals, led to the introduction of two training programs, one to supply more efficient nursing personnel trained in the new techniques used to treat mental illnesses and the other to supply a trained junior staff which could relieve nurses and doctors of the more routine duties.

The first group — called psychiatric nurses in most hospitals — usually hold the same professional standing as the registered nurse. Both men and women follow a course of study, lasting from two to three years, that in many respects is similar to the program of student nurses in general hospitals. The big difference is that a large proportion of the training time is spent in psychiatric studies.

The course of study for psychiatric aides and psychiatric attendants has been left to the individual hospital and so there is only a general uniformity. For this reason the course may vary in length, depending on the amount of responsibility the hospital expects the aide or attendant to assume. A survey of programs now in effect shows that the training period in hospitals varies from ten months to two and a half years. The course of study is generally similar in outline to the training given to nursing aides. Classroom instruction, usually lasting for several weeks, and covering such subjects as nursing techniques, psychiatry, and occupational and recreational therapy, is followed by a longer period of demonstration and practice in the wards. Many hospitals have arranged for their students to spend some weeks in a general hospital so as to have a broader experience.

Prospective students should be at least 17 years of age. In some hospitals a student is required to have Grade 8 standing; in others Grade 9 or 10. All applicants must pass a test to see that they have the health and stability required for this type of nursing. Classes begin at regular intervals but students are often accepted between these intervals on a probationary basis.

In most cases students receive room and board, uniforms and a small allowance during the training period. At the end of the course a certificate of standing is granted to the graduate.

Further information may be had by writing to the Superintendent of Nurses of any mental hospital, or to the provincial Department of Health. The provincial centres listed on Page 20 of this monograph will also be able to furnish information on schools where psychiatric training is available.

Orderlies

The status of the orderly, or nursing orderly, varies with the type of hospital and the qualifications of the man. The two great wars have done much to break down the former concept of the orderly as a person with little formal training who did the heavy lifting, moved equipment, and carried out personal duties for male patients. The Second World War and the immediate post-war period, drew many men into the occupation to take care of the sick and wounded in military and veteran hospitals. The favourable conditions in these hospitals, and the important and interesting duties to be done, have improved the status of the occupation, and an increasing number of men are turning to it as a life work.

At the request of the orderlies themselves in some cases, and in the interest of patients, a few hospitals are now giving their orderlies a course similar to that given the nursing assistant, but with emphasis on their particular duties.

The Department of Veterans Affairs has a well-established program of training for nursing orderlies for the men's wards and female nursing orderlies for the women's wards. In that Department's hospitals, nursing orderlies are classified as Grade I, II, III or IV, according to the duties they perform, their experience and training. The nursing orderly starts as a Grade I. A basic course in simple treatments and in the care of patients is given to workers who desire it. This means some 45 hours of lectures on theory and the practical application of it in the wards, the time being divided about equally.

From time to time, the Grade I nursing orderly is given the opportunity to study additional subjects with a view to upgrading. These will include such subjects as surgical dressing, oxygen therapy, X-ray work, etc. Some may specialize in a

particular phase of the work, operating-room technique or the giving of special treatments.

During the training period, the orderly's pay continues, and he is entitled to such Federal Civil Service benefits as superannuation, three weeks' vacation, and sick leave. He works a 44-hour week.

Photo: N.F.B.

In the Diet Kitchen.

ENTERING THE OCCUPATIONS

Entry into all non-professional occupations in hospitals may be through personal application to the matron in charge of the hospital or the personnel officer, if it is a large institution; the local newspapers or certain widely-read publications will carry requests for workers; or contact may be made through the local National Employment Service office. In addition,

those interested in employment in a Federal Government operated hospital should watch the circulars posted in public buildings, or make application to the Civil Service Commission.

As previously mentioned, those seeking training may apply to the various provincial directors of training or to the schools where training courses are given.

The Nurses' Registry in some localities may direct trained workers to employment.

EARNINGS

The earnings of the auxiliary nursing staff will vary with the locality, the size of the hospital, the particular duties and the responsibility placed upon the workers, and unionization. Housekeeping, clerical, and maintenance staffs, both skilled and unskilled, are paid at prevailing rates for similar work in that community.

Some hospitals provide meals, or give them at reduced rates during the work-shifts, supply uniforms, and give free medical and surgical treatment. An increasing number of hospitals now have contributory pension schemes in effect.

With reference to specific wages being paid, counsellors, students and applicants should make use of the following reference material: *Wage Rates, Salaries and Hours of Labour in Canada*, published annually by the Department of Labour, Ottawa; *Census of Canada* 1951, Vol. 5, and the *Annual Report on Hospitals in Canada* 1952, Vol. 2, Dominion Bureau of Statistics, Department of Trade and Commerce.

ADVANCEMENT

In the majority of non-professional jobs in this field, apart from those of the tradesmen, the duties of the various occupations are not yet standardized, so that it is difficult to establish a progressive channel of advancement. As a rule the advancement is confined to an increase in pay through increased responsibility or seniority. In most classifications there is in large establishments the opportunity of working up to a position in charge of a group of workers.

Persons classified in the lower grades of the technician group are limited in so far as they are adept in one operation only.

However, through additional training, the technician may in time assume the supervision over other technicians or may advance to work of a more complex nature.

The nursing assistant may better herself by taking special courses of study leading to a technician's job. Perhaps the most satisfying position for the nursing assistant is in a small hospital or nursing home, where she may be given scope to expand her knowledge and serve her patients. Many leave hospital employment to work on private cases in the home, or in welfare centres, clinics, day nurseries, or as a nurse in a doctor's office.

Psychiatric aides and attendants can better their positions through study and specialization. Knowledge and experience both count in this field.

Orderlies may work up to a position in charge of a group of orderlies or may undertake special duties such as those in the operating room, or in giving special treatments.

In D.V.A. hospitals, nursing orderlies usually start in as a Grade I and may advance from there to Grades II, III or IV according to their training, responsibilities and the size of the establishment. Smaller hospitals may call for a complement of Grades I and II, with possibly a Grade III in charge of orderlies; in larger ones, a Grade IV or Chief Orderly will carry these responsibilities.

ADVANTAGES AND DISADVANTAGES

It is difficult to assess the advantages and disadvantages in the field of hospital occupations, as the duties and conditions of work are so varied. Of necessity, discipline is strict, and a high degree of courteous efficiency is demanded.

A girl who lacks the required educational qualifications to become a registered nurse, but has the desire to serve the sick, will find much satisfaction as a nursing assistant. On the other hand, the person who has no motive apart from having a job may find the work uninteresting and depressing.

In some hospitals, certain categories of staff, in others all of them, must live in, and so are under continual supervision and restriction. Some people welcome the opportunity of having accommodation provided, while others prefer the freedom of making their own arrangements. Employees who live out very

often complain that transportation to and from work is a problem, as many hospitals are built on the outskirts of municipalities.

The training a nursing assistant receives is never lost. It is invaluable when there is sickness in the home, and may also lead to a means of livelihood, if, through misfortune, she loses her means of support. Many women, particularly widows, some with children, do "practical nursing" in the home, or in a hospital on a full-time or part-time basis.

The person with psychiatric training is not likely to have any difficulty in finding employment as it is an expanding field. However, the person who lacks outside interests may in time find the atmosphere of a mental hospital depressing.

The technician may find the work varied and interesting.

Many women and men who are prepared for routine work only are much happier doing this type of work in a group rather than alone in a home.

Improved living conditions, the trend towards unionization, the provision of hospital care when ill, and the fact that some institutions provide pension plans similar to those enjoyed by their professional staffs, are establishing these occupations on a more favourable basis.

A decided disadvantage in the eyes of many is that, of necessity, hospitals must operate on a 24-hour day, 7-day week basis. This means that shift work is required in most occupations.

In the majority of cases these occupations are non-insurable under the Unemployment Insurance Act. According to rulings, a non-profit institution, such as are municipal and government-operated hospitals, may elect to make contributions for all or certain categories of workers, but only a very small percentage of them have done so. On behalf of their members, unions are pressing for this benefit.

LABOUR ORGANIZATION

Non-professional workers in this field are, as yet, not well covered by labour organizations, owing to the fact that in the past there has been a heavy turnover of hospital employees. In recent years, workers in some of the larger hospitals have joined national or international unions on an industry rather than a craft basis. Also, a hospital staff may organize an employees' union or council for bargaining purposes.

X-ray technicians may join a provincial branch of the Canadian Society of Radiological Technicians, or the Canadian Association of Radiologists; the pathology technician may join the Canadian Society of Laboratory Technicians.

TRENDS

Growth

While complete statistical information, by occupations, is not available, some idea of their numerical growth and importance may be gained from the following statements.

According to a report[1] 1,145 hospitals of all kinds in Canada reported to the Dominion Bureau of Statistics. This was an increase of 157 since 1943. During the same period, the number

Photo: N.F.B.

The supply staff at work.

1. Dominion Bureau of Statistics, *Annual Report of Hospitals, 1952*, Vol. 1.

of hospital beds was increased by approximately 36,000 indicating that hospitals had not only increased in number but also in size. The largest increase in hospital accommodation was in the general type of hospital which is a large employer of non-professional personnel.

At the 1951 census date there were 25,648 "practical nurses" (including domestic nurses, maternity nurses, orderlies, ward maids, etc.), gainfully occupied in Canada. Of this number, 90 per cent were employed in hospitals.

Geographical Distribution

The location of hospitals across Canada is linked with the density of population. General hospitals and nursing homes will be found in most districts, but the concentration of these will be in the older and more settled parts of the country. City hospitals, because of their size and the diversity of treatments given, have an extensive break-down of duties and staff requirements. It is estimated that 40 per cent of the semi-professional and non-professional workers in general hospitals are located in seven cities: Halifax, Montreal, Toronto, Winnipeg, Regina, Edmonton and Vancouver.

Hospitals other than general are not so evenly distributed, as their location is dependent on the local demand for such an institution, the population served, or suitable climatic conditions — tuberculosis and mental hospitals will be in small towns or on the outskirts of a city; homes for the chronically ill are largely in densely populated districts where there is an adequate flow of patients for this type of institution.

The majority of job opportunities were found to be in the general type of hospital. Mental institutions were the second largest employer followed by tuberculosis hospitals.

Age Distribution

According to the 1951 census, of those registered as "practical nurses", more than 29 per cent were between the ages 17 and 24 and 54 per cent were between the ages 25 and 54.

Among the staff will be a certain percentage of older people, mostly First World War veterans, who are employed as orderlies, and elevator operators and on the kitchen and housekeeping staffs.

Present Labour Demand and Supply

It is evident that the acute shortage of workers that was so keenly felt during the war years, and in the immediate post-war period, has been to some extent alleviated. Any substantial shortage of workers that has occurred recently has been due mainly to the reluctance of workers to accept the working conditions prevailing in a particular locality, or to the competition of more favourable job opportunities.

Technicians are in steady demand as replacements, and to fill positions in new and enlarged laboratories and departments.

Trained orderlies who show evidence of wanting to stay on the job are not plentiful. Nursing assistants have little trouble in becoming established, especially in small country hospitals where there is a strong demand for them.

Many trained psychiatric aides and attendants are required by mental hospitals for their expanding program and the present supply of workers falls short of the immediate needs.

Employment Prospects

The employment outlook for workers in these occupations is very good. The field is an expanding one. As a result of changing living conditions, the public has accepted the use of hospitals as normal in case of illness. This is especially true of a growing urban population of apartment or small-home dwellers. The increased use of pre-paid hospital insurance has meant that many persons who formerly were unable to pay for hospital care are now demanding it, and the hospitals are strained to capacity to meet this demand.

Hospitals, and the treatment of illnesses, have also changed. New expensive equipment, complex treatments and new drugs make it imperative that patients be treated in institutions — sometimes in a particular institution for a specific treatment. Clinics are now rapidly becoming established in connection with out-patient treatment at hospitals and with county and municipal health work (e.g. baby and child clinics); these draw upon certain classes of semi-professional and non-professional workers.

The transfer of some routine and non-nursing duties from the registered nurse and the student nurse to workers of the non-professional level, in order to conserve scarce professional

nurse power, has created a need for many auxiliary workers, people who, with specific training, can make a definite and valuable contribution to a smoothly working team designed to give better care to the patients in our hospitals.

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AUDIO-VISUAL MATERIAL

Readers desiring information on film sources, available material and the organization of local film services may obtain it from the National Film Board offices listed in Monograph 1, "Carpenter".

LOCAL INFORMATION

LOCAL INFORMATION

"CANADIAN OCCUPATIONS" SERIES

The monographs listed below, accompanied by pamphlets, except in the case of numbers 12 and 13, have been published to date. Those from 20-35 have been published collectively.

(1) Carpenter
(2) Bricklayers and Stone-Masons
(3) Plasterer
(4) Painter
(5) Plumber, Pipe Fitter and Steam Fitter
(6) Sheet-Metal Worker
(7) Electrician
(8) Machinist and Machine Operators (Metal)
(9) Printing Trades
(10) Motor Vehicle Mechanic and Repairman
(11) Optometrist
(12) Social Worker
(13) Lawyer
(14) Mining Occupations
(15) Foundry Workers
(16) Technical Occupations in Radio and Electronics
(17) Forge Shop Occupations
(18) Tool and Die Makers
(19) Railway Careers

Careers in Natural Science and Engineering: (20-35)

(20) "Agricultural Scientist"
(21) "Architect"
(22) "Biologist"
(23) "Chemist"
(24) "Geologist"
(25) "Physicist"
(26) "Aeronautical Engineer"
(27) —
(28) "Chemical Engineer"
(29) "Civil Engineer"
(30) "Electrical Engineer"
(31) "Forest Engineer and Forest Scientist"
(32) "Mechanical Engineer"
(33) "Metallurgical Engineer"
(34) "Mining Engineer"
(35) "Petroleum Engineer"

(36) Hospital Workers (Other than Professional)

DEPARTMENT OF LABOUR

Economics and Research Branch

OTTAWA, 1954

OTTAWA
EDMOND CLOUTIER, C.M.G., B.A., L.PH.,
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY,
1954

CANADIAN OCCUPATIONS

★

DRAUGHTSMAN

MONOGRAPH 37

DEPARTMENT OF LABOUR, OTTAWA

CANADIAN OCCUPATIONS

★

DRAUGHTSMAN

★

MONOGRAPH 37

HON. MILTON F. GREGG, V.C., MINISTER
A. H. BROWN, DEPUTY MINISTER
DEPARTMENT OF LABOUR, OTTAWA

FOREWORD

During recent years there has been a steadily increasing demand for up-to-date information on occupations.

This demand comes from youth faced with the need of choosing an occupation and of selecting the type of training required; from parents, teachers and other counsellors; from workers shifting to other occupations; from employment service officers; from directors of personnel and union officials, and from other quarters.

This series of monographs and an accompanying series of pamphlets, the latter containing similar information in a condensed form, are attempts to meet this demand.

These publications represent an expansion of an earlier series issued by the Department of Veterans Affairs to assist members of the armed forces returning to civilian life following the end of the war. These current series, designed for general use, cover a wide range of occupations, including professions. They indicate, among other things, the nature of the occupations or group of occupations, entrance and training requirements, working conditions and opportunities in each.

This monograph, as was the case in those which preceded it, was prepared by the research staff in the Occupational Analysis Section.

The assistance of representatives of management and of trade unions in checking basic material, together with the assistance of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour and the Dominion Bureau of Statistics, is gratefully acknowledged.

DIRECTOR,
Economics and Research Branch,
Department of Labour.

March, 1955.

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A draughtsman at work Photo C.N.R.

HISTORY AND IMPORTANCE

When men found that "rule-of-thumb" methods no longer sufficed for the buildings, vessels and weapons they wanted, their intelligence must have been set to work to find some means, after visualizing the desired product, of planning its parts in relation to one another, and setting down in visual form the image of the whole and of its parts. Without doing this Noah could hardly have built his ark or the Egyptians their pyramids.

The advent of formal geometry, and of accurate measuring and drawing instruments were aids to the artists who were responsible for the drawing of plans for naval construction, building construction of all kinds, engineering undertakings such as ports, bridges and aqueducts, and for the making of maps. Later, men trained in draughting plans for such projects took over this field of work from the artists and developed a technique that is important to industrial progress.

The "blue-print" is an accepted necessity in the making of any manufactured article and few houses are built without detailed plans. Each part of a machine, large or small, must be meticulously set forth in a drawing before the skilled tradesman can begin the process of its manufacture.

The use of graphs of varying kinds is general in business and government circles, wherever a graphic comparison of figures is required. In the sciences, notably in biology, geology and physics, the services of draughtsmen are often needed. The importance of this work in mapping is very marked.

FIELD OF WORK

The services of the draughtsman are now required in almost every industry. By far the largest number are engaged in the metal working industries — heavy iron and steel, automotive, aircraft and machinery-building plants. The construction industry, which includes the building of private homes, apartments, factories, and public and commercial buildings, ships, docks and equipment, dams, roads, bridges, and other large projects, also employs a large number of draughtsmen. A smaller number of workers are to be found in certain branches of mining, transportation, and service industries; the other major industries, agriculture, logging, fishing, trade and finance, employ an almost negligible number of draughtsmen.

Municipal, provincial and federal government departments employ a substantial number of draughtsmen for the purposes of drawing up plans for the development of their particular sphere of interest — city planning, public utilities, land contours and the development of natural resources. Government research laboratories usually have a staff of draughtsmen for graphic presentation of developments and the results of enterprises. Engineering and architectural firms, doing their own or contract work, will maintain a staff of draughtsmen in proportion to the professional staff.

KINDS OF DRAUGHTING

While basic principles are employed by all draughtsmen in all industries, the wide variation in the finished product — from a needle to a battleship — and the vast amount of technical knowledge

that is required for each, have brought about specialization within the broad field. There are four major divisions. These in turn are broken down into smaller occupational specializations, the title of each indicating the particular type of work being done.

From the point of view of numbers employed, the largest group of workers are engaged in what is called *Mechanical Draughting* or *Machine Draughting*. This is the drawing of mechanical devices with the necessary accurate scale drawings of parts and of the whole, of machinery, motors, and tools; automobile and aeroplane bodies; engineering projects; structural features of mines; petroleum production, refining and pipe lines; lay-outs for wiring diagrams and schematics of various types of radio, radar, television and other electronic installations.

The range of industries in this field is so great that the general title, mechanical draughtsman, is broken down into subtitles which indicate the industry or particular process within the industry such as draughtsman (auto body) and draughtsman (engineering).

The drawing of artistic, architectural and structural features of towns, bridges, highways, public utilities, buildings, ships — not only the project itself but of its custom-built fixtures, plumbing, electrical wiring, heating, ventilating, refrigeration and landscaping — are the work of the *Architectural Draughtsman.*

Specialization again is made necessary by a wide range of projects and materials. In the domestic and commercial building field may be found such occupational specializations as *commercial draughtsman* (lay-out of offices and factories), *construction* (homes and buildings), *tile and marble, heating* and *ventilating, plumbing, refrigeration, reinforced concrete, landscaping.* The whole field of marine draughting (ships and docks) is in many ways similar to general construction, but factors of durability and serviceability have singled it out as a particular field. Specializations are *hull, hull-ballast, hull stress calculation, hydraulic, sheet metal,* and *ship engineering.*

Cartographical Draughtsmen draw maps — geographical, topographical and for special purposes.

The term *Design* is sometimes used to denote the specialized field of the reproduction of experimental ideas of the research engineer.

THE DRAUGHTING ROOM

The place where a draughtsman does most of his work is called a "draughting room" or "draughting office". Depending on the requirements of the establishment, it may be just a corner of the general office or shop, any little room where one or more draughtsmen carry on their duties or, at the other extreme, a large room with the latest in equipment and a large staff of workers.

The draughting room is usually designed for convenience and good lighting, both natural and artificial. The furnishings are simple—draughting tables and stools, tracing tables, and file cabinets for the storage of drawings. Some firms will have special time-saving equipment while others will depend on the basic instruments of the trade — drawing boards, tee squares, scales, triangles, French and other irregular curves, protractors, compasses, dividers, and reference books.

The draughting room is rarely established "on location" in the case of projects being carried on in isolated areas; the engineer's notes are sent to a central office and the work is done there.

The personnel of a large draughting office will consist of a chief draughtsman and an assistant chief draughtsman, checkers, draughtsmen of various degrees of skill and specialization, junior draughtsmen, apprentices, tracers, filing clerks and office boys.

DUTIES

The *chief draughtsman* and his assistant must be qualified draughtsmen. It is their duty to administer the draughting room and to assign work, to co-ordinate the work of their department with that of the other departments, and to consult with engineers, administrators and members of their own staff.

Checkers are experienced draughtsmen who are familiar with the requirements of the industry. They check the work of the draughtsmen.

The duties of the *draughtsmen* will vary with the industry, specialization and the size of the establishment — in a large office the work will likely be departmentalized while in a smaller one it will be less specialized.

In general, the duty of the draughtsman is to convey, through the medium of drawings, the ideas of the engineer, inventor, designer or architect, to the men who must do the work. These "ideas" may be given to him by word of mouth, notes or sketches. This will usually entail a series of drawings showing how the object or project will look when finished, how it will look from various angles and in cross-section, the structural features beneath the outer covering, and detailed drawings of movable parts.

The established signs and techniques of the trade are used to denote the exact meaning, the dimensions, materials to be used, and all other pertinent information that the workers will need.

Of course, the design draughtsman frequently originates ideas and collaborates with engineers in developing plans.

Junior draughtsmen may be learners or persons whose skill has not reached the level of a draughtsman. *Tracers* are employed to make copies of drawings and to do other routine work.

Classroom instruction in draughting Photo N.F.B.

TRAINING

On-the-job training is usually supplemented by formal courses of study. Draughting is not a "designated trade", (i.e. one that comes under the compulsory regulations of the provincial Apprenticeship Act), in most provinces, and so there is a great variation in the way training is given. However, many employers who hire junior draughtsmen or apprentices have them sign an agreement, and follow a training procedure similar to a formal apprenticeship program.

In most establishments the training period is from two to four years. During this time the trainee works under the close supervision of a qualified draughtsman. Progress is made from the simple to the more complex drawings as the trainee learns the principles of the trade and the use of the various instruments and reference books. In some companies the trainee is required to spend part of the training period in the shop under the instruction of a qualified mechanic or production worker so as to become familiar with the machinery and materials he will be concerned with in his work. This period of practical shop experience is most desirable.

Where possible, employers arrange that trainees spend one or two evenings a week studying draughting or related subjects at the local vocational school; a few will send their employees to a provincial trade school for a short period, arrange for a course with a correspondence school or, if there are a number of trainees, hold regular classes in their own plant.

In some cases allowance is made for the time spent in courses, but as a rule these are taken on the student's own time. An employer may provide books.

Graduates in draughting from the Ryerson Institute of Technology in Toronto, the Calgary Institute of Technology and Art, and similar institutions are sometimes accepted by employers as junior draughtsmen.

Courses in a wide range of draughting subjects are given by commercial correspondence schools, and cost from $100 up.

Correspondence courses, covering various phases of draughting, are available from the Departments of Education of Nova Scotia, Quebec and British Columbia. These have been compiled to meet Canadian standards and conditions, and are available at a reasonable price.

The courses prepared by Quebec Province are in French.

The following courses are now available from provincial Departments of Education:

	Cat. No.	No. Lessons	Prerequisite
Nova Scotia			
Architectural Draughting			
Part I	37	9	Grade IX Math. or equivalent
Part II	38	13	Part I or equivalent
Part III	39	9	Part II or equivalent
Mechanical Draughting			
Part I	44	10	Grade IX Math. or equivalent
Part II	45	12	Part I or equivalent
Part III	46	15	Part II or equivalent
Sheet Metal Draughting			
Part I	51	10	Grade X Geometry or equivalent Mech. Draughting, Part I or equivalent
Part II	52	10	Part I
Naval Architecture (elementary)	49	15	Grade XI Math. or equivalent Knowledge of ship construction
Blueprint Reading	40	20	Grade IX Math. or equivalent
Quebec			
Dimensional Sketching	41	15	Grade IX or equivalent
Vertical Lettering in Industrial Drawing	42	30	Elementary Education
Machine Parts	43	10	Grade IX or equivalent
Blueprint Reading	50	13	Grade IX or equivalent
Shop Drawing	53	15	General Knowledge of Technical Drawing
Drawing, Technical or Industrial	54	20	Grade IX
British Columbia			
Mechanical Drawing			
Part I	47	20	High school students
Part II	48	20	Part I or equivalent

Those interested in further information should write to the following provincial official:

The Supervisor,
Correspondence Study Branch,
Box 221, Halifax, N.S.

J. S. Robitaille, — Director,
Correspondence Course Bureau,
506 St. Catherine Street East,
Montreal 24, P.Q.

Dr. Edith E. Lucas,
Director of Correspondence Instruction,
Weiler Building,
Victoria, B.C.

It is customary for students to supply their own instruments and handbooks. Usually it is not necessary for these to be purchased at the beginning of the training period.

QUALIFICATIONS

The prospective draughting student should be at least 16 years of age and under 30 years.

Both men and women are accepted for training. This is an occupation that is open to persons with certain physical handicaps.

A good general education is needed. Students who have graduated from a technical or trade school are in particular demand because of their knowledge of industrial crafts, draughting and practical mathematics.

Some employers stipulate that trainees must have completed Grade 9, others require Grade 12 or 13 high school standing. Night school and correspondence school courses in draughting and related subjects are sometimes accepted in lieu of certain other educational qualifications.

To become a good draughtsman one needs to have a genuine interest in the various aspects of the trade and possess some artistic ability. One must be thorough, accurate and neat. A constructive imagination and the ability to analyse are very important in this occupation.

ENTERING THE OCCUPATION

Employers make their requirements known to the office of the local National Employment Service, or place advertisements for

student draughtsmen in the newspapers. Also a person may ask for an interview with a company that has a draughting office, and place an application for a position when one becomes available.

Notices of openings in government departments and special courses leading to government employment are posted in local post offices and other public buildings.

It has become the practice of many firms to place their requirements for student draughtsmen with the placement officer of a vocational or trade school. Many successful students have jobs awaiting them when the term is finished. Teachers of night schools and private correspondence schools may recommend successful students to an employer.

Some young people will get a start in draughting through serving as office boy or file clerk or even as a learner in another department of a firm.

SALARIES

Salaries will range from the relatively low wage paid to tracers, junior draughtsmen and apprentices to a salary that will compare favourably with that of other skilled workers. The natural ability of the worker, his education, the degree of specialization, experience and the amount of original work required will have a bearing on the wage paid. Also, the type of industry and its geographical location will have a certain influence on wages.

Apprentices' wages are set as a percentage of the draughtsman's wage and increases are granted at 6 or 12 month intervals until the end of the training period.

In the government service and in many public and private concerns, pensions, sick leave and holidays form part of the contract. Some firms will also include company participation in paid health schemes and other benefits.

ADVANCEMENT

The progression of the draughtsman is from the simple operations to the more complicated ones to the supervisory field, — apprenticeship (if there is a scheme in operation), junior draughtsman, tracer, learner or filer to draughtsman to checker to assistant supervisor to supervisor.

The draughtsman can usually expect some advancement in pay and status for experience, ability and specialization; the supervisor may improve his position by joining a larger office staff where there will be more responsibility. Where there are a number of draughting sections, each section reports to a draughting supervisor who in turn reports to a senior engineer.

ADVANTAGES AND DISADVANTAGES

Working conditions usually are clean, bright and airy; the hours of work and vacation periods are similar to those of the general office worker; the rate of pay is on a par with wages in comparable positions demanding similar abilities.

Draughtsmen usually enjoy steady employment and are not so subject to seasonal slack or depressed periods in employment as are many production workers. Their services are required well in advance of production or construction. Employers hesitate to release draughtsmen when work is slack as key personnel may be difficult to replace when operations are resumed.

It is an interesting and varied field of work for those who find satisfaction in drawing and planning things.

The work may be hard on the eyes, and may induce poor posture. Also, workers are expected to spend long periods of time stooped over a drawing board. Management is trying to alleviate these conditions with well-placed windows, modern lighting and proper desks.

RELATED OCCUPATIONS

The draughtsman's skill relates him to many trades within industry yet it is not easy to shift from draughting to anything else without additional training. Because of the extensive specialization that exists in the field, transferability from one specialization to another is made more difficult. A direct application of the acquired skills, with further study, would lead to the occupations of industrial designer, architect, engineer or surveyor. Draughting experience is an excellent background if a person wishes to switch to the mechanical or administrative side of industry.

Draughtsmen may practise their trade in the armed forces or may turn to teaching it in technical or vocational schools.

LABOUR ORGANIZATIONS

For the most part, draughtsmen are not well organized. There is, however, the International Federation of Technical Engineers AFL-TLC.

In many instances draughtsmen are represented, along with workers in other occupations, by a plant union.

TRENDS

Growth

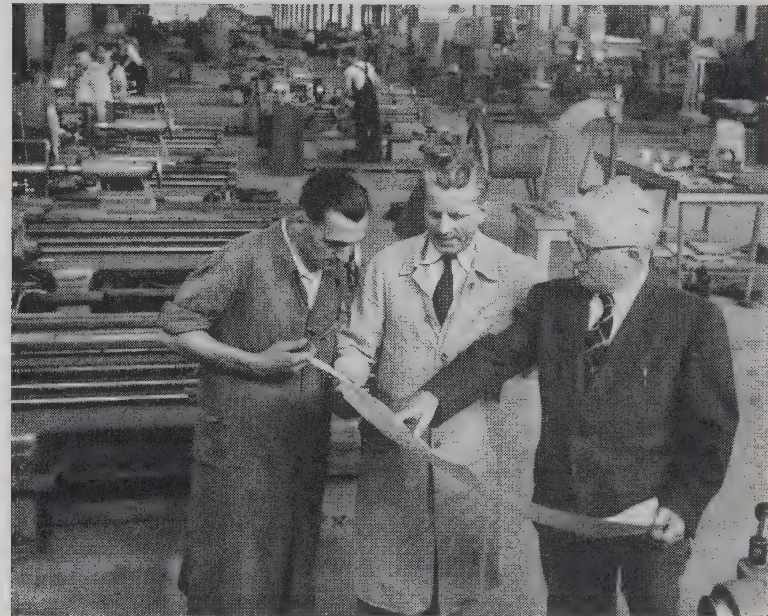
Draughtsmen, which in the Canadian census includes both skilled designers working in a wide range of media and some workers not thoroughly trained as draughtsmen, have greatly increased in number in keeping with Canada's population and industrial development. The censuses of 1921, 1931 and 1941 show that there were at the reporting periods 3,203, 4,701 and 6,192 persons respectively in the occupation. By 1951 the number of draughtsmen had risen to 13,012, a gain of 110 per cent during the 10 year period between 1941 and 1951.

The greater number of opportunities for employment are in the established industrial areas of the country although a draughtsman's craft may take him to any part of Canada. According to the 1951 census, industries in Ontario and Quebec together employed 81.8 per cent of the total workers in this occupation. At that time draughtsmen were distributed as follows: Ontario 50.9 per cent, Quebec 30.9, British Columbia 6.9, Alberta 4.3, Manitoba 2.9, Nova Scotia 1.6, Saskatchewan 1.1, New Brunswick 1.0, Newfoundland 0.3, and Prince Edward Island 0.1.

In the decade between 1941 and 1951 the general distribution pattern was relatively unchanged. There was, however, a greater increase in the Prairie Provinces reflecting the stepped-up industrial expansion in that region.

According to the 1951 census, the greatest number of workers were found to be in the larger cities where most of the larger industries are located. Draughtsmen in Montreal, Toronto, Hamilton and Ottawa together comprised almost 34 per cent of the total workers in the field; more than 50 per cent were located in 13 cities and 53 per cent in 16 cities. A comparison of the distribution in

1941 and 1951 brings out the interesting fact that there are now more opportunities for employment for those who live outside the larger centres.



Manager, master mechanic and tool maker check blue-print for specifications
Photo N.F.B.

Industrial Distribution

As indicated in the following table, the bulk of the workers are employed in manufacturing; half of these in the manufacture of iron and steel products and transportation equipment. The next largest group is classified as being in the service industries which include workers in community, government, business, and personal enterprises.

Between the reporting dates in 1941 and 1951 there have been some changes in the proportion of workers in the various industries. For instance, in 1941 only 58 draughtsmen were employed in mining, quarrying and oil wells; in 1951 there were 311. During the same period workers in electrical apparatus and supplies rose from

432 to 1,141; wholesale and retail trade from 89 to 514; electricity, gas and water from 182 to 785. The number of draughtsmen employed in the construction industry remained relatively unchanged.

NUMBER OF DRAUGHTSMEN BY INDUSTRY IN CANADA, CENSUS 1951

	Total	Male	Female	Percentage
All Industries	13,012	12,379	633	100.0
Agriculture	26	25	1	.2
Forestry & Logging	77	74	3	.6
Mining, Quarrying & Oil Wells	311	285	26	2.4
Manufacturing	7,912	7,624	288	60.8
Iron & Steel Products	2,635	2,604	31	20.2
Transportation Equipment	1,315	1,284	31	10.1
Electrical Apparatus & Supplies	1,141	1,067	74	8.8
Electricity, Gas & Water	785	747	38	6.0
Construction	613	603	10	4.7
Transportation	403	396	7	3.1
Communication	242	137	105	1.9
Trade, Wholesale & Retail	514	471	43	4.0
Finance	61	59	2	.6
Service	2,817	2,674	143	21.7
Government	1,290	1,227	63	10.0
Business	1,430	1,363	67	11.0

Age

By far the largest proportion of workers in this occupation are in what is considered to be the younger age group. According to the 1951 census almost 69 per cent of the workers were 34 years of age or younger, and 25 per cent were between 35 and 54 years of age. This preponderance of workers who have yet many years of service ahead of them can be attributed to the large number of young people who entered the occupation during the industrial expansion of World War II and the immediate post-war period.

Sex

Until very recent times draughting was considered to be an occupation almost exclusively restricted to men. Even as late as 1941, according to the census of that year, only 157 women were employed in the occupation. During World War II the shortage of young men who were available for employment in this trade, encouraged employers to hire and train young women to fill their requirements. They were, of course, carefully placed in positions where they could be used to the best advantage. Because of their

neatness and artistic ability many of them proved themselves to be particularly suited to this work, and thus opened up what was previously an almost closed field to women. In 1951, men still made up the bulk of the total workers in the field (97 per cent in 1941 and 95 per cent in 1951), but the number of women who were employed had increased during the ten year period from 157 to 633.

Labour Demand and Supply

A shortage of workers in this occupation was evident in the immediate post-war years. Now the demand is mainly for workers to fill openings in new plants, and for the regular turnover of workers.

The National Employment Service records, late in 1954, showed a surplus of applications over vacancies. Some of the surplus may be accounted for by the limited knowledge of draughting possessed by some applicants. Also, qualified workers are often unable to move to regions where there are openings for draughtsmen. Some of the larger centres reported that there was still a demand for well qualified mechanical and electrical draughtsmen.

Consulting the blue-print for the next step of a construction project

Photo N.F.B.

Future Employment Prospects

In the light of present day advances — industrial growth, complicated mechanisms, new materials, the development of national resources and the modernization of transportation and public utilities, all of which require the services of general and specialized draughtsmen — it will be seen that draughtsmen operate from a wide base of industrial development. There is, however, no indication that a shortage of draughtsmen will materialize in the near future.

In the past, when the draughting occupation was in its infancy in this country, Canada drew heavily on trained draughtsmen from other countries. According to the 1941 census, about 31 per cent of the total recorded were born outside Canada, some 24 per cent in Britain; the corresponding percentages in 1951 were 24 per cent and 15 per cent.

While the wide range of activities requiring the services of draughtsmen constitutes some guarantee of stability in employment, too much emphasis cannot be laid upon the necessity of thorough training.

CONCLUSION

It is desirable that a person thinking of entering this occupation should try to get a position with an organization which has an established training program, or at least make sure that the company plans to give a progressive training. Once established, the trainee should make every effort to improve his knowledge. The competition is keen, and the requirements are becoming more exacting.

REFERENCES

The Guidance Centre, Ontario College of Education, Toronto, Monograph, *Machine Draftsman.*

Science Research Associates, Chicago, Occupational Briefs, *Draftsmen.*

United States Department of Labor, Bulletin No. 998 *Occupational Outlook Handbook,* (1951 edition), *Draftsmen* pp. 99-100.

AUDIO-VISUAL MATERIAL

Readers desiring information on film sources, available material, and the organization of local film services may obtain it from the National Film Board offices listed in Monograph 1, "Carpenter".

LOCAL INFORMATION

"CANADIAN OCCUPATIONS" SERIES

The monographs listed below, accompanied by pamphlets except in the case of numbers 12 and 13 have been published. Numbers 20-35 are in a single volume.

(1) *Carpenter*

(2) *Bricklayers and Stone-Masons*

(3) *Plasterer*

(4) *Painter*

(5) *Plumber, Pipe Fitter and Steam Fitter*

(6) *Sheet-Metal Worker*

(7) *Electrician*

(8) *Machinist and Machine Operators (Metal)*

(9) *Printing Trades*

(10) *Motor Vehicle Mechanic and Repairman*

(11) *Optometrist*

(12) *Social Worker*

(13) *Lawyer*

(14) *Mining Occupations*

(15) *Foundry Workers*

(16) *Technical Occupations in Radio and Electronics*

(17) *Forge Shop Occupations*

(18) *Tool and Die Makers*

(19) *Railway Careers*

Careers in Natural Science and Engineering: (20-35)

(20) "Agricultural Scientist"

(21) "Architect"

(22) "Biologist"

(23) "Chemist"

(24) "Geologist"

(25) "Physicist"

(26) "Aeronautical Engineer"

(27) —

(28) "Chemical Engineer"

(29) "Civil Engineer"

(30) "Electrical Engineer"

(31) "Forest Engineer and Forest Scientist"

(32) "Mechanical Engineer"

(33) "Metallurgical Engineer"

(34) "Mining Engineer"

(35) "Petroleum Engineer"

(36) Hospital Workers (Other than Professional)

(37) Draughtsman

DEPARTMENT OF LABOUR

Economics and Research Branch

OTTAWA, 1955

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CAREERS IN DRAFTING

occupations, Monograph 3

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Canadian Occupations
Monograph 37

CAREERS IN DRAFTING

First Edition 1955: Draughtsman
Revision 1962

Prepared
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of the
Department of Labour, Canada

HON. MICHAEL STARR
MINISTER

GEORGE V. HAYTHORNE
DEPUTY MINISTER

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FOREWORD

During recent years there has been a steadily increasing demand for Canadian occupational information. The demand comes from young people faced with the need of choosing an occupation and preparing for it; from parents, teachers and vocational guidance counsellors; from workers wishing to change their occupations; from employment service officers; from personnel directors and union officials; from prospective immigrants to Canada and from other quarters.

The CANADIAN OCCUPATIONS series of monographs is designed to help meet this demand. Each booklet describes, among other things, the nature of the occupation or groups of occupations, entrance and training requirements, working conditions and employment outlook.

The series has been prepared with the generous assistance of representatives of management, trade unions and professional associations. The co-operation of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour, and the Dominion Bureau of Statistics is gratefully acknowledged.

Occupational information tends to become dated as a result of changes in economic conditions, in industrial technology and in wage and salary structure. Revision of outdated publications is a regular feature of the series.

This booklet was prepared for the Manpower Resources Division by Alvin Styles and William Allison of the Occupational Analysis Section. The help and co-operation of many organizations and individuals working in the drafting field are gratefully acknowledged.

J. P. FRANCIS,
Director,
Economics and Research Branch,
Department of Labour.

January 1963

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All modern products require drafting. Thousands of separate drawings, representing as much as half a million man-hours of work, go into the building of an aircraft. Photo: Canadair.

CAREERS IN DRAFTING

HISTORY AND IMPORTANCE

A simple article such as a bolt or the complex structure of an ocean liner first takes shape on the drawing board. It is there that mental images are given their first rough form and tested for feasibility, solutions to problems are worked out, and final working drawings are completed.

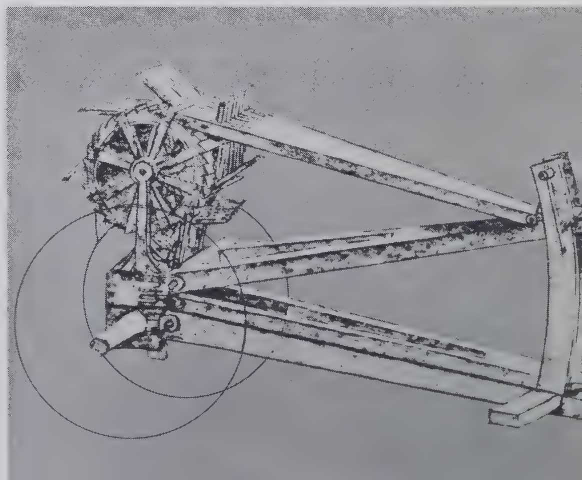
Technical drawings are the universal language for communication in industry. They include necessary information as to size, shape and structure of the whole object and all its parts, needed by the workers who may build, operate or repair it.

Man's first written communication was a form of picture writing, an example of which is Egyptian hieroglyphics. The pictures eventually became simplified to form the characters of alphabets which now form the visual symbols of our spoken languages.

Whilst the written and spoken word is fairly satisfactory for everyday communication (despite frequent misunderstanding), words alone are quite inadequate to convey the kind of scientific or engineering information required in industry. An interesting test of verbal skill is to have someone try to describe, using words alone, a simple household article, the corkscrew. Most people will grope hopelessly for the right words yet, given pencil and paper, might *draw* a recognizable corkscrew—without using any words! However, it would require a person skilled in the art and techniques of engineering drafting to produce drawings that could be used by skilled technicians and craftsmen to develop the machines and methods for mass production even of corkscrews, let alone the complex machines and products of modern industry.

Thus man, in order to achieve the high degree of industrialization we have today, had to develop a system of pictorial representation. The modern form of technical drawing is a refined technique that grew out of the rough sketches and plans first used to visualize mental images forming in the human mind.

Drawings and sketches must have been used by the ancients for their construction work; the Romans made working drawings of their viaducts, bridges and fortresses; and we have records of maps made by early mariners and explorers of the seas and land masses of the world as they knew it—or imagined it!



Perspective drawing of an early automatic gun by Leonardo da Vinci. Photo: NFB.

The genius of Leonardo da Vinci—philosopher, artist, scientist, engineer and inventor—found expression in many ideas for machines which have since been perfected. Proof of his inventive mind is recorded in the many drawings he left behind. You will note that the type of drawing shown here conveys only the general idea of the machine and does not give the accurate measurements and detail work usually found in modern technical drawings.

Such rough drawings might be adequate when a single craftsman makes the entire article and is able to work out details for himself. With the introduction of mass production techniques and specialization of skills, many more workmen are involved in the production of an article. These include designers, engineers, technicians, craftsmen and machine operators, each contributing their particular skills in the work of production.

This has increased the need for a good means of communication—the technical drawing—so that all workers know exactly what is required of them. Since the drawing reaches into all aspects of industry, technical workers should be able to read blueprints and, in some instances, render technical drawings.

The increasing complexity of modern products and production methods, including automation, is not only increasing the amount of drafting necessary, but it is requiring greater technical skill and knowledge on the part of draftsmen. Senior draftsmen have become more than "drawers of things"; their role has increasingly evolved toward the design of either tools, machine parts, or manufacturing methods.

NATURE OF THE WORK

Drafting, in its simplest elements, consists in putting lines on paper to represent position, form, movement or direction, together with symbols and data to represent certain functions, processes or instructions. To a draftsman, a dot means position; a dot moving in space is a line; a line moving in space is a plane; and a plane moving in space is space itself. These are the fundamental concepts with which a draftsman works.

The time-honoured skills of draftsmen are to render the lines and symbols quickly, neatly and accurately. To do this they use

a variety of drafting instruments, including T-squares, triangles, rulers, ruling pens, drafting machines and precision tracing equipment. Modern innovations have taken some of the time-consuming drudgery out of drafting. Ready-made symbols, labels, shaded backgrounds, etc., are now available for rapid paste-up. Photographic and microfilming processes are eliminating tedious tracing and the traditional "blueprinting". Nevertheless, draftsmen are still expected to have these basic skills and use them when necessary.

More important, however, is the function of draftsmen in working from technical information contained in rough sketches, specifications or verbal instructions and translating it into finished drawings to be used for various purposes.

Technical drawings are inevitably related to technical fields, for example, electrical, mechanical, mapping or building construction. That is, drafting is carried out according to the scientific and engineering principles which apply to the project. In addition, drawings in each technology have special methods of presentation and employ their own unique conventional symbols. It follows, therefore, that drafting skill rests upon a good knowledge of the technology involved, plus a familiarity with the

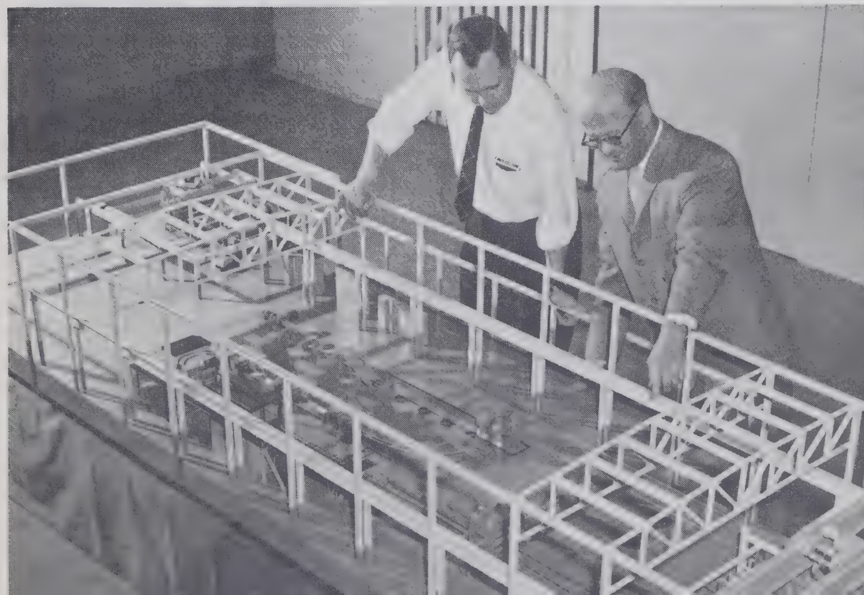
The draftsman translates ideas for products into drawings. He depends upon his knowledge of materials, machine design, mathematics and mechanics to produce working drawings. Photo: Canadair.

drawings in other technologies that might affect the work, e.g., wiring and heating ducts having to be installed around structural beams.

Before putting pencil to paper, draftsmen must understand perfectly what is the purpose of the drawing or chart; what the designer, engineer or scientist has in mind; how much information to include; they must anticipate technical problems and work out solutions to them. They may use scientific or engineering knowledge and make calculations, using engineering slide rules, calculators, handbooks and tabular data. The drawing and sketching they do is often an aid to thinking out solutions to problems.

Drafting principles and techniques are applied in many different fields, the main ones being *engineering, architecture,* and *mapping*. Engineering drafting is the preparation of working drawings for various kinds of engineering projects such as construction work, production machinery and processes, and manufactured products. Architectural drafting is the development of various types of drawings for buildings. Map drafting, or cartography, as the name implies, includes the preparation of maps and charts for a variety of purposes. Another somewhat related field is the preparation of charts and diagrams for pictorial presentation of statistical data.

A draftsman and planning engineer examine the scale model of a new copper rod rolling mill. Photo: Northern Electric Company Limited.



Engineering Drafting

Engineering drawing is the general term used in the industrial world by engineers and designers as the formulae in which are expressed and recorded the ideas and information necessary for the building of machines and structures. It is a graphic representation in which exact and positive information is given regarding every detail of a structure or machine to be built.

Engineering draftsmen are a link between the engineer or designer who works out ideas for products or structures, and the workers who will do the fabricating or building. The role of the draftsmen may best be described by tracing the development of an imaginary product from the point where it is but an idea, to the point where production begins.

The procedures described in the following diagram, it must be remembered, may vary from plant to plant, depending on the complexity of the product, the size of the design and development staff, and the general organization of the plant.

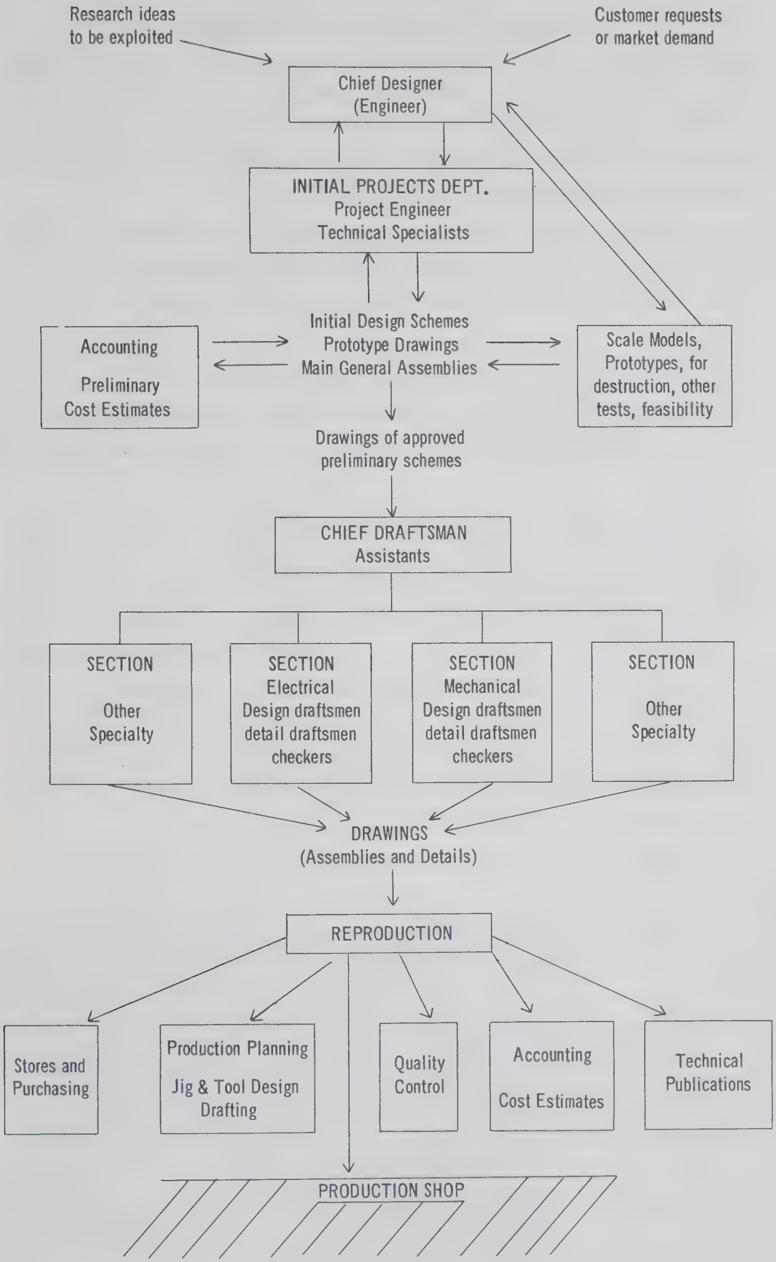
Ideas for products come from inventors, from customers whose requests lead to the conception of useful products, and from research laboratories which originate new ideas to be exploited.

New product ideas are first submitted to the chief designer (usually an engineer) who works closely with an initial projects department headed up by a project engineer. The project engineer may be supported by specialists in stressing, materials, power systems, etc., depending on the nature of the product.

The design work done by the initial projects department results in initial design schemes of the product, including prototype drawings and main general assemblies. These drawings may be used to build scale models or pilot plants which are tested to determine feasibility, performance, durability and, possibly, the potential market for such a product. Similar drawings may be submitted for preliminary cost estimations to determine whether the project is economically feasible.

When preliminary schemes are approved, they are passed to the drafting office for the development of working drawings.

DESIGN AND DEVELOPMENT OF AN INDUSTRIAL PRODUCT



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The Drafting Office

Work in the drafting office is supervised and directed by the chief draftsman and possibly an assistant chief draftsman. Depending on the complexity of the product and the technologies involved, the drafting staff may be composed of a number of sections, each specializing in a certain aspect of the drawings—electrical, mechanical or other specialty.

Each section is responsible for preparing the working drawings in its area of specialization—with due consideration for co-ordinating with the work being done in other specialties.

From the various drafting sections come an assortment of general assembly and detailed drawings which are checked and prepared for reproduction. These drawings are destined to play an important part in the work of several other departments of the plant.

Sets of drawings will be sent to the production planning department to be used by workers who must design the necessary jigs, tools, dies and other production machinery and prepare additional drawings needed by tool and die makers. Details of shop processes, assembly procedures and scheduling will also be worked out from information on working drawings. Drawings will also be sent to quality control for development of inspection procedures, to the stores and purchasing department, to cost estimation for final costing, and to technical writers who will prepare operating and servicing manuals.

Manager, master mechanic and tool maker check a blueprint for specifications. Photo: NFB

Drafting Personnel

The degree to which drafting work is divided among the various personnel depends on the size of the staff (some drafting departments are small, others have hundreds of draftsmen) and the complexity of the drafting work. One company may use a drafting pool and project system where all draftsmen are in a common pool, and as a project is assigned, a group leader draws draftsmen from the pool as required. Another company might have their staff divided into drafting sections, each with a section leader, two or three checkers, six or seven draftsmen and two or three juniors.

Chief draftsmen supervise and direct the operation of the drafting office. They estimate the overall drafting workload to determine if objectives can be met, if additional staff is required, or whether some work should be sent out for contract drafting. They assign drafting projects according to the abilities and specialties of the drafting staff; give technical advice to draftsmen; co-ordinate the work of the drafting department to other departments (liaison); and take responsibility for seeing that new draftsmen are properly trained.

Generally speaking, *design draftsmen* work from the approved preliminary sketches and accompanying data and models to develop initial design drawings that will satisfy the requirements and specifications for the product. They must solve problems of space, weight and construction limitations, and in many cases determine the strength of materials to be used in the various parts. This requires a working knowledge of technical production methods, the ability to interpret information in scientific and engineering handbooks, and will often involve considerable calculation.

General assembly drawings are usually supplemented by a number of other drawings which give much more detail for the construction of small components or subassemblies than is possible in general assemblies. This work, done by *detail draftsmen* or *detailers*, constitutes a complete description of each separate piece giving its shape, size, material, shop operations necessary, limits of accuracy, and quantity required.

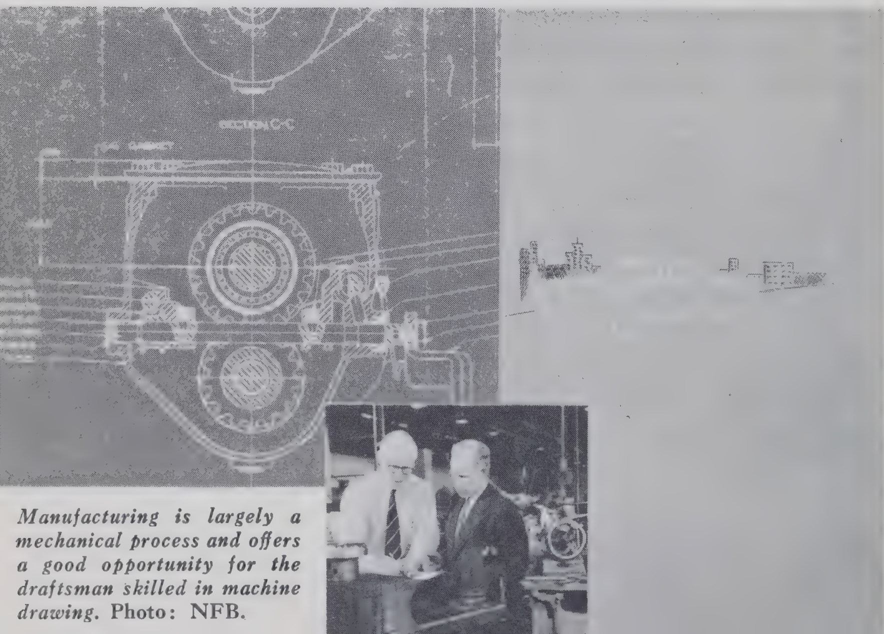
The pencilled drawings are carefully checked for errors and omissions. The *checker*, who must be a well-qualified and experienced draftsman, examines the drawings to ensure that each piece is correctly described and represented; checks all dimensions by scaling and computation; checks tolerances, finishes, interferences; sees that standard and stock items have been specified wherever possible.

After the drawings are checked, and the engineer concerned has given approval, they are submitted for reproduction so that copies can be sent to the various plant departments.

Engineering Drafting Specialties

As mentioned previously, drafting is related to the technology in which the draftsman is working. Engineering embraces a number of technologies, of which the main ones are: mechanical, structural, electrical, electronic, aeronautic, and marine. Each technology has its own symbolic drafting language and calls for specialized knowledge on the part of the draftsman. In time, therefore, draftsmen tend to become highly specialized, making it difficult for them to move from one technology to another without further study.

Mechanical drafting is basic to most engineering work, since most projects have important mechanical aspects to be dealt with. It is mainly applied to industrial machines, machine parts, engines

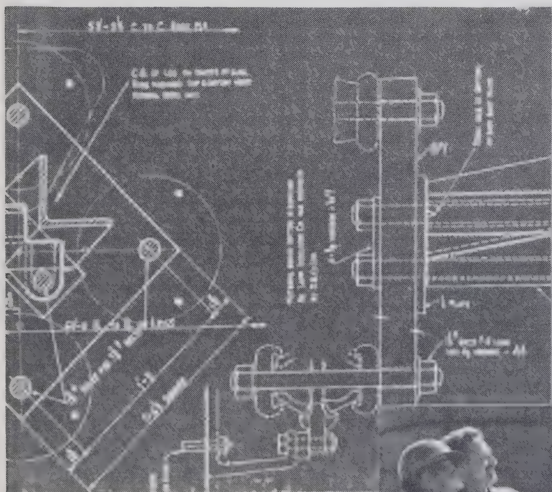


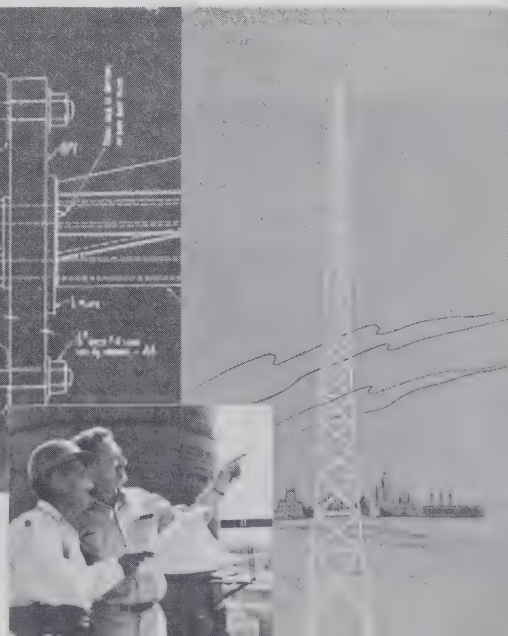
Manufacturing is largely a mechanical process and offers a good opportunity for the draftsman skilled in machine drawing. Photo: NFB.

and other mechanical equipment, including the design of machine tools. It is important in mechanical drafting to have a working knowledge of pattern and casting procedure, sheet metal and plate fabricating, welding and machine shop practice, and metals including alloys and their working properties. Familiarity with such machine elements as gears, levers, pulleys, hydraulic and pneumatic systems is also important.

Tool Design drafting is a specialized branch of mechanical drafting involving machine tools, cutting and forming tools, as well as jigs and fixtures used in conjunction with industrial machines. A good knowledge of various machine tools and manufacturing processes is essential.

Civil engineering is a broad field and includes most types of drafting. One of the important specialties is *structural* drafting which is concerned mainly with drawings of the framework and supporting members of buildings, bridges and transmission towers. These drawings give detailed instructions for the cutting, punching, assembling, bolting, riveting, welding and erecting of each of the many members making up the complete structure. Structural draftsmen must have special knowledge of building materials such as steel and concrete, and be able to indicate methods and proper locations for making rivet holes, welds, joints and reinforcements. Since structural components such as girders, beams and columns are often prefabricated in a plant and shipped to the construction site for assembly and installation, structural draftsmen must be





Is construction going according to plan? What will the next step be? The answers are found in the working drawing. Photo: NFB.

familiar with on-site construction methods and problems. They must also see that the design of the structure conforms with building codes and safety factors, and indicate methods for fastening exterior covering material such as marble, glass or sheet metal.

Other drafting in civil engineering is concerned with drawings for projects such as highways, railways, subways and tunnels, dams, reservoirs, irrigation systems, sanitary and storm drainage, town planning and airports.

Electrical drafting covers a wide range of drafting jobs, many primarily consisting of designing or drawing mechanical features of electrical equipment. A general knowledge of physics as it pertains to the behaviour and characteristics of electricity and magnetism is essential. Many mechanical components have an electrical function or affect the electrical performance of the equipment. The draftsman must be familiar enough with the specific technology, both mechanical and electrical, to translate the general ideas or instructions of the engineer into working drawings.

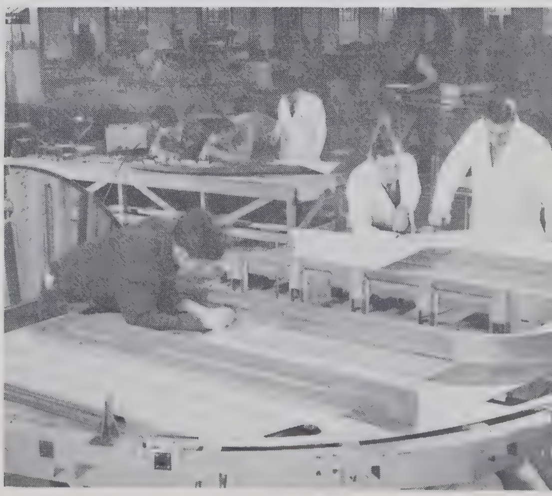
A specialized branch of electrical drafting consists of layouts, wiring diagrams and schematic drawings for electrical installations. These show wiring, circuits, and arrangement of control panels and other electrical components. In power utilities, certain draftsmen are more directly concerned with generating stations and transmission lines, which call for interpretation of survey notes, topographical maps and aerial photos.

An equipment installer uses a wiring diagram to produce the "Bay Form" for a relay rack.
Photo: Canadian Pacific.

A knowledge of circuitry and symbols, electrical safety codes and other factors related to electrical engineering are required in electrical drafting.

Electronic drafting is distinguished from electrical drafting in that it is mainly concerned with equipment in which the electrical flow (electrons) is emitted, controlled and directed through tubes and semi-conductors (transistors). Electronic draftsmen prepare drawings to convey information and instructions needed for building, installing, operating and servicing electronic equipment such as radio, television, computers and navigational controls. Design work for this equipment presents a variety of problems which are not found in other branches of engineering drafting. These problems are related to the generation, propagation, detection and amplification of electromagnetic waves ranging from low to ultra-high frequencies, to subminiature components and large computer installations, and to the growing application in industry of electronic controls.

Aeronautical drafting is concerned mainly with aerodynamics as related to designs for the exterior shape and internal supporting structures of aircraft. It also involves the adaption of other mechanical, electrical and electronic components to aircraft design. Three-view exterior outlines, subassemblies such as wing and tail construction, and numerous other kinds of drawings are needed in aircraft construction. Aeronautical draftsmen must be familiar with the variety of materials and equipment as well as the shop operations and practices used in aircraft manufacture.



***Drawings provide the reference from which assemblies such as this aircraft bulkhead can be built.* Photo: de Havilland Aircraft of Canada Limited.**

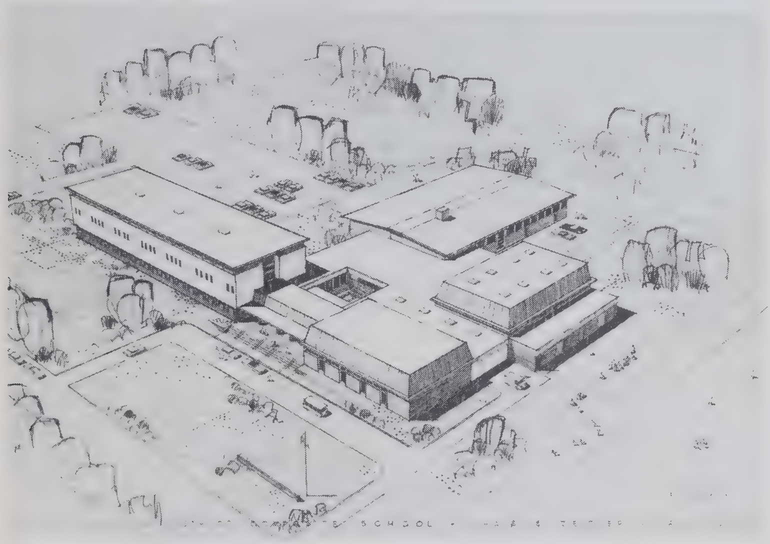
Plans are essential in shipbuilding—whether it is a scale model or an ocean liner.
Photo: NFB by Gar Lunney.

Marine or naval architectural drafting is in some respects similar to aeronautical drafting. Considerable technology is involved in the exterior shape of the ship's hull, design of internal supporting structures, and adaption of other mechanical, electrical and electronic equipment to ship design. In this work, the *hull draftsman* is the central figure, as he specializes in drawings for all details of the construction, fabrication and erection of the hull of a ship and all its related parts. This includes preparing body and line plans for design studies, assisting in hydrostatic stability and strength calculations, and developing diagrammatic system drawings. Marine draftsmen need a good knowledge of shipbuilding and ship repair techniques, production methods and outfitting procedures.

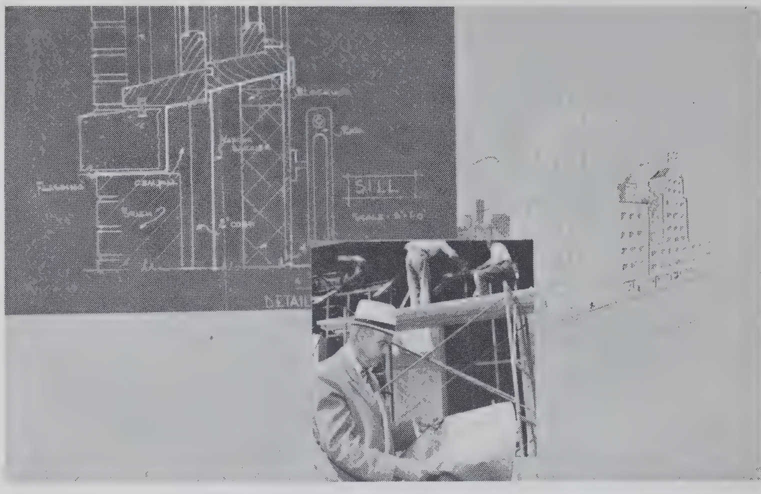
Another specialized application of engineering drafting includes sheet metal work for heating, air-conditioning and ventilation, and other equipment and furnishings made from sheet metal. Drawings show the finished objects and also the shape of flat sheets which, when curved, folded and fastened, will form the object.

Architectural Drafting

Architectural drafting is concerned with the preparation of drawings and specifications for buildings and structures, including pictorial as well as diagrammatic arrangement. As in engineering, architectural draftsmen also serve as a link, this time between the architect who designs buildings, and the building tradesmen.



Based on an understanding of the client's requirements and wishes, and with due consideration for utility and artistic blending with surrounding landscape or adjacent buildings, the architect develops a preliminary design for a building. From this, the *architectural draftsman* prepares preliminary sketch plans for the client's consideration and approval. Preliminary sketches include general design and exterior appearance, and plan layout of the proposed structure. Draftsmen also prepare *display* and *competition* drawings, which are a more elaborate type of preliminary drawing, showing plans and elevations. These are often in perspective, without working information, and may be done in water colour, ink, pencil or air brush.



Architectural drawings have many uses—to show the client what the finished building will look like, to help contractors estimate the cost of construction, to guide foremen and tradesmen who do the work, and to serve as records. Photo NFB.

Upon approval of the preliminary sketches the draftsman, working closely to the architect's instructions, prepares working drawings. These include floor plans, elevations, section and detailed drawings, showing the nature and extent of the project, materials to be used, locations and details of windows, cabinets, stairways, heating, plumbing and electrical outlets.

Architectural working drawings also have the important functions of recording clearly the client's requirements so that estimating and bidding are facilitated, and forming a part of the contract between the client and the building contractor.

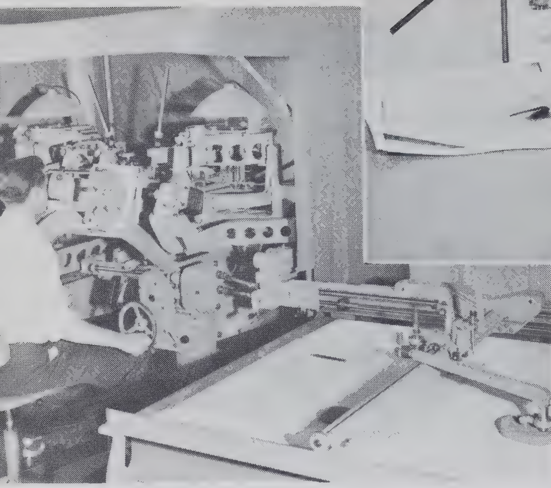
The organization of drafting personnel in a firm of architects may vary according to the size of the firm or extent of the project. Design work is usually the responsibility of the architect, assisted by a design draftsman. Other draftsmen prepare preliminary and working drawings, correlate them with drawings for the various trades, checks for completeness and accuracy, and prepare tracings. A *specifications writer* will prepare a list indicating materials, finishes, workmanship, and all working information for erection of the project.

Map Drafting (Cartography)

This branch of drafting is concerned with the various operations required for the production of maps and charts. Depending upon the organization of drafting staff and nature of information provided, these operations may include compiling, plotting, drawing and copying. Map drafting differs in an interesting and important respect from the drafting described previously. Whereas engineering and architectural draftsmen deal with the development of projects and products which do not as yet exist, *map draftsmen* produce scale drawings which record aspects of the earth's surface or crust which actually do exist. Map draftsmen are engaged in the development of geographic information as an end product in the form of maps and charts for a variety of purposes—topographic, hydrographic, geologic or navigation.

Early maps, made and drawn from observations by travellers, were often inaccurate and incomplete. Today, map and chart work is performed scientifically. Use is made of modern methods of travel; of electronics in field surveying; of the application of aerial photographs and photogrammetric instruments for plotting and compilation and of modern methods of map reproduction.

Photo: Geological Survey of Canada.



Above: Interpreting a vertical aerial photograph.
Left: Compiling a topographic base map with a precision photogrammetric plotting machine.

Photos: Survey and Mapping Branch, Department of Mines and Technical Surveys.

An important feature of map drafting is the preparation of *base map* outlines. These are made in any scale desired from aerial photographs by means of stereo-photogrammetric plotting equipment. The *plotter* guides a floating dot along shorelines, lakes, streams and other dominant topographical features appearing on a stereoscopic view of aerial photographs by manipulating horizontal and vertical controls. The path of the dot is traced on a sheet of drawing paper by a mechanically controlled graphite point. The resulting outline is an accurate scale reproduction of the same photographic features traced by the floating dot, and forms a base for the production of other maps on which is overlaid a variety of types of information.

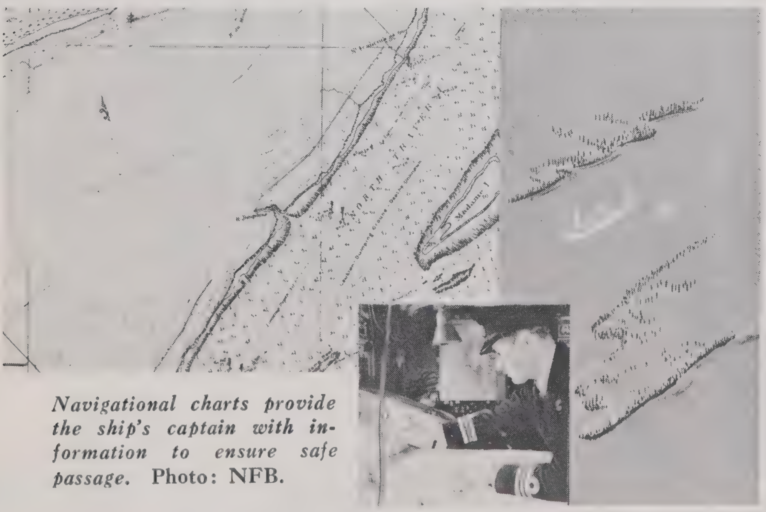
Topographical maps are drawn from field information as well as aerial photo data, to show contours of hills, valleys, mountains, streams, and cultural features such as roads, bridges, railways, and other man-made projects, and including boundaries of political divisions or other information required for special purposes.

Aeronautical charts are topographical maps overprinted with the locations of airports, beacons, radio beams and other navigational aids for air transportation. They also give details of

important topographical features such as altitude readings, railway lines, highways and rivers, which serve to identify to pilots the area over which they are flying.

Geological maps are very important to Canada's mining and petroleum industry. From manuscript maps prepared in the field, map draftsmen prepare finished maps indicating by various colours, patterns and symbols, the structure and makeup of the earth's crust, as well as information regarding the presence of metals, oil, natural gas and other materials. Readings from magnetometers carried from traversing aircraft provide information for aeromagnetic maps which are used in the location of ore-bearing deposits.

Hydrographic charts are made primarily for navigational purposes but also for various engineering or scientific projects such as marine construction, oceanography and defence purposes. From field sheets, prepared by hydrographers, containing a variety of information such as depth soundings, shoals, currents and tides and from other sources of information, hydrographic draftsmen select data to prepare a comprehensive chart of that part of the coast under survey. The chart, complete with numbers and symbols, will show the shoreline, landmarks, depths, shoals, lights, as well as all other relevant information which may help a ship's captain when he is using these waters.



Navigational charts provide the ship's captain with information to ensure safe passage. Photo: NFB.

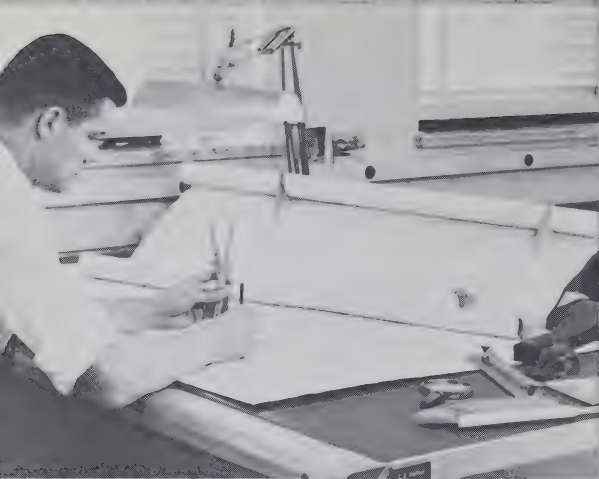


Photo: Geological Survey of Canada.

From information and data supplied from many different sources, map draftsmen prepare finished maps for printing. They engrave, scribe or draw outlines and selected details on paper and plastic sheets; paste in labels of place names and other printed legends; do free hand or mechanical lettering; prepare colour separation negatives for multi-coloured maps; and complete the work needed to provide the printer with finished materials for map reproduction.

Photos: Canadian Hydrographic Service.

PERSONAL QUALITIES NEEDED

Drafting is an occupation suitable for both men and women; the work is not physically hard, but requires a good degree of manual and finger dexterity.

Good vision, normal or corrected, is necessary to withstand lengthy periods of close detail work, often over a fluorescent tracing table. In mapping, stereo vision is necessary for stereo plotting—this can be checked on a three-dimensional viewer—and good colour vision is needed in preparing geological maps.

Neatness and *accuracy* are of paramount importance in drafting. Drawings must be clear, accurate and neat so that the craftsman who builds or makes the product can read them easily. Map negatives for printing purposes must be impeccably neat and accurate.

Drafting also requires *patience*—to stay with complex and detailed drawings in which progress may be slow; to accept the need for redoing drawings which may be changed numerous times before they are completed and approved; or to accept, with good grace, the need to stop work in the middle of a project and start on another more urgent one.

Tact and *ability to get along with others* are also important if the draftsman is part of an engineering team, and especially in the work of a checker, who may have to point out errors in the work of others.

The *ability to form mental images* of a planned project, and render them in pictorial form are important in design work. Students have ample opportunity to test their ability and interest in imaginative drawing when doing the many school assignments calling for charts, maps, and diagrams. For prospective architectural draftsmen, an *appreciation of art*, and *artistic ability* are considerably more important than in other types of drafting.

PREPARATION AND TRAINING

There is no standard qualification or certification for draftsmen, and there are many paths one may take to the occupation. The basic preparation is preferably high school graduation, although grade 10 is sometimes accepted. However, if the prospective draftsman is seriously interested in becoming proficient and

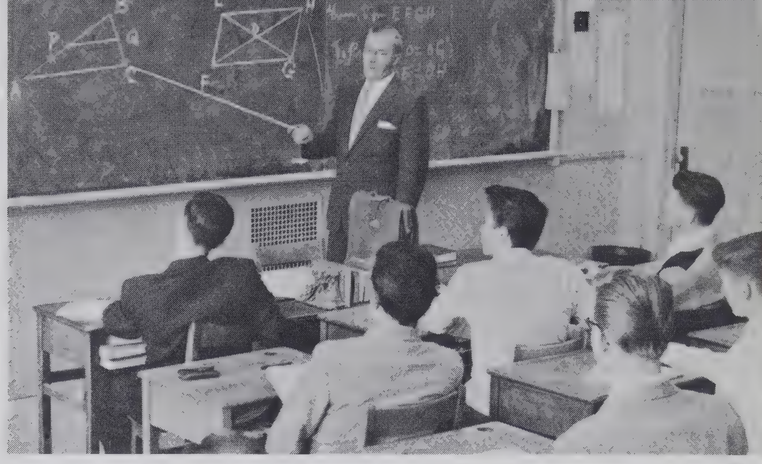


Photo: NFB.

wishes to advance to skilled drafting or designing, high school graduation is recommended as a basic preparation.

Secondary (High) Schools

In high school, courses in mathematics—arithmetic, geometry, algebra and trigonometry—are most important. It should be pointed out that in certain types of drafting, weeks may be spent in calculations before any lines are put down on paper. Proficiency in the use of the engineering slide rule is a useful skill for draftsmen to have.

Because so much of modern production is scientifically based, courses in physics are useful as a background for understanding stresses, forces, vectors, mechanics, and the physical properties of materials. Courses in geology and geography are helpful in map drafting, and art courses help develop skill in lettering, layout, sketching and neatness. Important, also, is the development of communication skills—the ability to express oneself clearly in speaking and writing.

Vocational Schools

In technical or vocational schools at the secondary level, students can take introductory drafting courses to develop skill in handling drafting instruments, and practical courses in shop mathematics and shop practice to learn something of the materials and processes of industry.

Post-Secondary Schools (Institutes of Technology)

At the post-secondary school level, it is possible, in some institutes of technology, to take a specific course in drafting. This would include instruction in the practical and theoretical aspects of mechanical drafting and design, structural drafting, and topographical and geological mapping. Such courses include practical machine shop experience, structural work, and field surveying.

Most institutes of technology include engineering drawing and blueprint reading as an integral part of the instruction in their two- and three-year technical courses at the post-secondary school level. Graduates of these institutes therefore have a good combination of knowledge in a technology and drafting technique for them to become design draftsmen, if this is the type of work they should come to prefer. Graduates of institutes of technology can expect to start at higher levels and progress further in their drafting careers.

Training on the Job

After acquiring a greater or lesser degree of drafting skill and technical knowledge, draftsmen must be trained on the job to bridge the gap between their education and the special drafting

Experience on the job is needed to become a proficient draftsman. Photo: NFB.

requirements of the employing firm. They must gain much more practical knowledge about the technologies involved, and become familiar with the firm's products and production processes.

It is common for junior draftsmen to take additional training in evening classes at a local technical school, or by correspondence study. Many firms expect and encourage them to do so by giving financial assistance with study courses. Draftsmen, the same as all other workers engaged in rapidly changing technologies, will find a constant need for advanced study in order to stay abreast of recent developments and keep their skills from becoming obsolete.

Correspondence Courses

Students wishing to learn drafting, but who do not have the opportunity to attend drafting classes, may take advantage of inexpensive correspondence courses offered by provincial Departments of Education. Details of these courses and instructions for obtaining them are contained in a booklet *Canadian Vocational Correspondence Courses,* available without charge from the Department of Labour, Ottawa, Canada.

* * * * *

For *engineering* drafting, the basic study course is mechanical drafting, from which later specialization in electricity, electronics, structures, aeronautics or marine drafting may be entered. Some firms have organized apprentice training programs for their junior draftsmen. These may include practical experience in the production shop, learning about the machinery, materials and processes they will be concerned with in their work. Also, apprentices in the machine shop or electrical trades—machinists, tool and die makers, patternmakers or electricians—may find their technical skill and knowledge useful for gaining entry to the drafting office as draftsmen.

For *architectural* drafting, students have the alternative of taking the two- or three-year course in architectural technology or the architectural drafting course offered at various institutes of technology. It is also possible, however, to become an architectural draftsman by training on the job in an architect's office.

But for a few basic courses in *mapping*, most map draftsmen must learn their skills on the job. In large mapping establishments such as those in the Federal Department of Mines and Technical

Surveys, there is considerable specialization. Some specialize in the operation of stereo-plotting equipment to produce base maps or do topographical contouring; others specialize in the preparation of geological maps, hydrographic charts, or various types of topographical maps.

ADVANCEMENT

To a great extent, a draftsman's progress depends on the degree of technological knowledge and drafting skill he brings to the job. The greater these are, the shorter will be his time as a junior draftsman and the higher he can expect to rise. The increasing complexity of modern production methods, together with the reduction or elimination of many simple entry jobs such as tracing, blueprinting or filing, make it more difficult for those wishing to start as beginners without previous training.

Starting as a junior draftsman, who is considered a trainee, it may take from three to four years on the job to become a competent draftsman. Duties and responsibilities will increase as experience is gained.

For those who have the technical competence, there is a path of advancement to work as checker or project leader; on the creative side, there is opportunity for advanced design work.

Those who show administrative ability together with technical competence may advance to group or section leader, then assistant chief draftsman and, for a few, chief draftsman, depending on the occurrence of openings at higher levels.

In the course of their work, draftsmen come into contact with scientists, engineers, contractors, executives, technicians and craftsmen. They may thus be stimulated and encouraged to take advantage of opportunities to better themselves in other fields. Extensive technical knowledge gained in the course of drafting may, with additional training, help them to prepare for interesting jobs in engineering, designing, sales, administration, or teaching.

Architectural draftsmen can, if they have senior matriculation, become professional architects by following a systematic course of study in conjunction with work as an architectural assistant and

passing examinations set by the provincial registering body. For further information about this form of advancement see *Architecture as a Vocation,* a booklet available on request from The Royal Architectural Institute of Canada, 88 Metcalfe Street, Ottawa, Ontario. Similarly, engineering draftsmen may become professional engineers by preparing, with private study, for examinations set by provincial registering bodies.

In map drafting, as well as other drafting specialties, advancement in the Federal Government is closely tied to on-the-job training and experience. A beginner must spend a minimum of two years as a Student Draftsman, two years as Draftsman 1, two years as Draftsman 2, taking at least six years to reach the Draftsman 3 level, depending on the occurrence of vacancies at higher levels.

WORKING CONDITIONS

Draftsmen are classed as "white-collar" workers. They work in drafting offices that are warm, usually well ventilated, and removed from the noise or grime of the production department. Needless to say, physical working conditions and general layout of drafting offices are designed to facilitate the best drafting results, and the nature of the work makes this easy to attain.

Drafting is light and mainly sedentary work; eye strain and poor posture from leaning over drawing boards are the only hazards.

Photo: Geological Survey of Canada.

SALARIES

Pay scales change frequently, are subject to geographical differences, and vary with the degree of responsibility. For current rates in a particular area or establishment, readers should refer to the National Employment Service, local employers, union officials or recent issues of the Department of Labour's publication Wage Rates, Salaries and Hours of Labour in Canada.

Draftsmen—All Industries

Average Weekly Salaries—October 1, 1961

Locality	*Junior* $	*Intermediate* $	*Senior* $
St. John's, Nfld.	55.04	—	87.24
Halifax, N.S.	65.26	75.80	94.22
Sydney, N.S.	84.80	95.53	108.17
Moncton, N.B.	69.38	84.24	97.47
Saint John, N.B.	65.53	78.78	100.43
Montreal, P.Q.	70.13	93.80	114.32
Quebec, P.Q.	64.53	86.93	106.09
Sherbrooke, P.Q.	58.61	70.23	110.05
Hamilton, Ont.	75.63	93.17	111.43
Kingston, Ont.	73.56	90.13	111.69
London, Ont.	58.82	79.53	98.64
Peterborough, Ont.	84.83	95.83	119.75
Sault Ste. Marie, Ont.	81.79	102.77	120.64
Toronto, Ont.	70.29	89.04	108.09
Winnipeg, Man.	64.19	84.42	107.19
Regina, Sask.	59.94	78.45	92.70
Saskatoon, Sask.	65.82	74.05	88.35
Calgary, Alta.	67.58	85.75	104.58
Edmonton, Alta.	68.40	83.14	103.86
Vancouver, B.C.	75.87	95.26	113.38
Victoria, B.C.	55.82	83.51	101.32

Federal Civil Service Annual Salaries for 1962

(*Includes Engineering, Architectural and Mapping*)

	$
Student Draftsman	2,580 to 3,300
Draftsman 1	3,570 to 4,020
Draftsman 2	4,290 to 4,740
Draftsman 3	4,920 to 5,640
Supervising Draftsman 1	5,430 to 5,970
Supervising Draftsman 2	5,970 to 6,510
Supervising Draftsman 3	6,330 to 6,990

SEEKING EMPLOYMENT

Young people seeking their first drafting job can register with the nearest local office of the National Employment Service, where they will be given every assistance in locating suitable employment. As the beginner will have no occupational experience to offer, chances for employment will be greatly increased if the lack of experience is offset by a good education and specific training in drafting—backed up by an impressive folio of drawings from school assignments.

At present, the demand is for senior draftsmen, but employers are giving more thought to training junior draftsmen for the needs of industry.

There are, from time to time, opportunities in the Civil Service of Canada for young people with high school education and a demonstrated aptitude for drafting, for positions as Student Draftsmen in architecture, engineering or mapping. Notices of competitions for these openings are posted in National Employment Service offices, Post Offices and other public buildings.

Drafting is also a trade for which training is available in the Armed Forces.

NUMBER IN THE OCCUPATION

Census of Canada figures from 1921 to 1961 indicate the following growth in the number of draftsmen in Canada:

1921	3,203
1931	4,701
1941	6,192
1951	13,012
1961	20,623

These figures reflect the growth of industrialization over the years. During the depression little growth took place, and at the outbreak of World War II the number of draftsmen was only about 6,000. During the war Canadian industry went into high gear and, with only a slight breathing spell, continued its expansion into the post-war period.

More than half of the total number of draftsmen are employed in manufacturing, most of them working in the fabricating industries—metals, machinery, transportation equipment and electrical products.

Since the greatest number of opportunities for employment are in the most industrialized areas, about 73 per cent of draftsmen are located in Ontario and Quebec; 9 per cent are located in British Columbia, 8 in Alberta, 2 in Saskatchewan and 4 in Manitoba; 4.3 per cent are in Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick.

Until recently, drafting was considered to be an occupation almost exclusively restricted to men. In 1941 only 157 women were employed in drafting; by 1951 the number had risen to 633 and in 1961, 866 women were employed in this field.

ORGANIZATIONS

In many cases, draftsmen may be organized, along with workers in other departments, by the union representing all workers in a plant. Many draftsmen, being highly trained, are inclined to align themselves with professional or technical groups, and may belong to the *Corporation des Techniciens de la Province de Quebec,* the Association of Certified Engineering Technicians and Technologists of Ontario, the Ontario Institute of Chartered Cartographers, or the Professional Institute of the Public Service of Canada.

EMPLOYMENT OUTLOOK

Canada is becoming increasingly industrialized, with a growing need for technically trained workers—of whom draftsmen are a good example. Furthermore, there is an increase in the amount of research and product development being done in Canadian plants. Added to this, more engineering is going into production work; products are becoming more complex; more working drawings are needed; and more detailed instructions are being supplied to production craftsmen and other workers.

For the past ten years there has been a relative shortage of well-qualified draftsmen, with good employment opportunities in this field. Opportunities for trainee draftsmen should improve as a result of the encouragement and assistance being given to industry in expanding their training facilities.

The outlook appears to be most promising for engineering draftsmen. It is in this area that Canada's development is moving ahead. Further industrialization, reflected in more manufacturing

and construction, should create a good demand for trained draftsmen, especially in the electronic, electrical and mechanical fields.

Architectural drafting will be tied to the building industry, which tends to fluctuate according to fluctuations in the country's economic activity. There is a trend toward less architectural work on residential buildings, but more toward town planning and urban renewal. An increasing interest in artistic industrial design may also create opportunities for draftsmen skilled in design work.

The field for map drafting is limited to the mapping activity of the federal and provincial governments, large oil and mining companies engaged in exploration work, and a few private firms doing contract mapping. However, the experience of Canadians in aerial photography and the related mapping of vast expanses of this country has led to some contracts for private Canadian firms to map the terrain and potential resources of under-developed countries.

Acknowledgements

The co-operation and technical advice of the following organizations, companies and government departments is gratefully acknowledged. Acknowledgement is also made to the many individuals who assisted in the preparation of this booklet and to the numerous publications used for reference.

Canadair Ltd.
Canadian Vickers Ltd.
Canadian Westinghouse Company Ltd.
Civil Service Commission of Canada
Department of Mines and Technical Surveys
Department of National Defence
Department of Transport
Dominion Bridge Company Ltd.
Dominion Structural Steel Division, Canadian Iron Foundries Ltd.
John Inglis Co., Ltd.
Link-Belt Ltd.
Northern Electric Company Ltd.
Saint John Shipbuilding & Dry Dock Company Ltd.
Technical and Vocational Training Branch—Department of Labour
The Royal Architectural Institute of Canada
Unemployment Insurance Commission
Women's Bureau—Department of Labour

CANADIAN OCCUPATIONS FILMSTRIPS

The Department of Labour has prepared, to date, the following occupational filmstrips in collaboration with the National Film Board. A manual has been prepared as an accompaniment to each filmstrip. These may be purchased from the National Film Board, Box 6100, Montreal, or from any one of its regional offices. Prices in Canada: $4.00 for colour; $2.00 for black and white.

Plumber, Pipefitter and Steamfitter

Careers in Engineering (revised in colour)

The Social Worker

Electrical and Electronic Occupations (in colour)

Bricklayer and Stone-Mason

Printing Trades

Careers in Natural Science (revised in colour)

Careers in Home Economics

Motor Vehicle Mechanic

Mining Occupations

*Draughtsman

Careers in Construction

Machine Shop Occupations

Sheet-Metal Worker

Careers in Meteorology

Medical Laboratory Technologist (in colour)

Teacher (in colour)

Office Occupations (in colour)

Electronic Computer Occupations (in colour)

Careers in Library Service (in colour)

*A visual presentation of the essential facts in this booklet.

CAREERS IN DRAFTING

Monograph No. 37

CANADIAN OCCUPATIONS

WELDER

★

MONOGRAPH 38

DEPARTMENT OF LABOUR, OTTAWA

CANADIAN OCCUPATIONS

★

WELDER

MONOGRAPH 38

HON. MILTON F. GREGG, V.C., MINISTER
A. H. BROWN, DEPUTY MINISTER

DEPARTMENT OF LABOUR, OTTAWA

45

PRINTED IN CANADA

FOREWORD

During recent years there has been a steadily increasing demand for up-to-date information on occupations.

This demand comes from youth faced with the need of choosing an occupation and of selecting the type of training required; from parents, teachers and other counsellors; from workers shifting to other occupations; from employment service officers; from directors of personnel and union officials, and from other quarters.

This series of monographs and an accompanying series of pamphlets, the latter containing similar information in a condensed form, are attempts to meet this demand. These publications are designed for general use and cover a wide range of occupations, including professions. They indicate, among other things, the nature of the occupation or group of occupations, entrance and training requirements, working conditions and opportunities in each.

In the case of this monograph the assistance of representatives of management and trade unions, together with the assistance of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour and the Bureau of Statistics, is gratefully acknowledged.

DIRECTOR,
Economics and Research Branch,
Department of Labour.

April, 1955.

WELDER

HISTORY AND IMPORTANCE

Welding has a long history. It is very difficult to establish how far back this process of uniting metals by fusion was known and practised by workers in metal. However, we do know that a forge-welding process known to the Egyptians was developed some seven hundred years ago by a Frenchman named Moyeure.

It was not, however, until the turn of the twentieth century and the advent of such discoveries as gas welding, oxyacetylene welding, electric-arc and machine welding that welding as a method of joining metals became accepted as an important industrial technique. The two World Wars gave tremendous impetus to this occupation in all the metal-working industries.

Photo: N.F.B.

A welder at work.

There are several methods used in the joining by fusion of two metals. These methods are described briefly as follows: (1) the contact surfaces of the parts to be joined are heated so that the metal will melt, flow together and unite. Various sources of heat may be used such as gas, oxyacetylene or electric-arc; (2) the pieces to be joined may be heated to the required working temperature and then hammered together. This is known as forge-welding; (3) two metals may be bonded together substituting pressure for heat. This is known as the cold-welding process; (4) a soft alloy, such as solder may be melted then allowed to flow along the edges for the parts to be joined. This is known as soldering; (5) Brazing is another method used to join broken parts. Soldering and brazing differ from welding in that no actual fusion of the parts takes place but rather they are joined by the adhesion of a solder. Brazing results in a closer, and therefore, stronger union than is the case with soldering.

Welding as an occupation enjoys a favourable position in Canadian industry. Apart from its war-time uses it is needed in such peace-time industries as the automotive, iron and steel, heavy machinery, shipbuilding and construction.

Welding has now replaced rivetting in many instances because it is a faster and more efficient method of bonding metal for many jobs. Since no holes need to be drilled in the metal as is the case with rivetting, welding brings about a stronger and more permanent union of metals. In shipbuilding welding permits the use of lighter plates thereby increasing the carrying capacity of ships. In the construction of large buildings, bridges, etc. steel members that were formerly always rivetted are now frequently being welded. Automobile bodies, coaches and engine cabs of trains, as well as the frame-work, fuel tanks and landing gear of aeroplanes are all being welded today. Welding crews also travel across the country joining long-distance pipelines that are used to transport oil and natural gas. Many machine parts which were formerly cast in one piece are now being welded from steel plates, enabling firms to turn out a lighter and stronger finished product at lower cost.

DUTIES

The main duty of the welder is to fuse metal pieces together or build up worn parts. Specific tasks are: selecting pieces for welding; cleaning these parts to free them from dirt, slag, oil and rust by chipping, wire brush or chemical solution; bevelling edges of pieces by grinding, filing or cutting with oxyacetylene torch; setting up the welding equipment and welding the broken or worn parts, or the new pieces to be joined.

A welder may have to preheat some metals depending on their characteristics to prevent distortion during the welding process. In electric-arc welding the welder must control the flow of current from the power supply. He must also be familiar with the use of direct and alternating current equipment.

Various titles are given to welders. These titles are usually associated with the nature of the work being done, the type of metal being worked on or the welding equipment being used.

Some of the various titles are as follows: oxyacetylene welder, aluminum welder, electric-arc welder, gas welder, spot welder, track bonder, track welder, welder bonder, maintenance welder, pipeline welder, and ship welder.

TYPES OF WELDING

There are five main types of welding techniques. These are known as: oxyacetylene, electric-arc, resistance, thermite and pressure welding. The following is a short summary of these different welding procedures:

Oxyacetylene Welding

The oxyacetylene welder connects his torch to tanks of oxygen and acetylene, (on each of these tanks is a control valve to regulate the flow of gas); selects the proper torch tip for the work to be done and fits it onto the welding torch, (the mixing of the gases occurs in the welding torch); thoroughly cleans the parts to be welded, built up or cut; places them in position; plans the sequence of welding and/or cutting operations; determines the melting and welding characteristics of the metal

being worked on; lights the torch with a friction lighter; welds, cuts or brazes metal; fabricates metal sections or builds up worn parts. The intense heat caused by passing the flame over the area being welded causes the metal to melt and thus fuse together the parts being welded. Should it be necessary, additional metal can be added by melting a rod of metal identical with the parts being welded or built up.

Photo: N.F.B.

A welding repair job.

Electric-Arc Welding

The arc welder sets up, adjusts and operates all types of portable electric-arc welding equipment to join or assemble, repair and/or build up worn spots on various types, thicknesses and shapes of metal; fastens parts to be welded in proper posi-

tion for welding operation; selects proper rod for the job and inserts in electrode holder; fastens the other electrode to part being welded; selects hood and adjusts same over eyes; touches electrode to metal, then immediately withdraws it a short distance to "strike" the arc. The heat produced at the arc melts the metal from both the welding rod and in the area being welded causing fusion. The arc welder then guides the arc along the part to be welded making an even "bead" by controlling the length of the arc and the amount of metal being deposited from the welding rod. When the weld is completed, the welder breaks the circuit by withdrawing the electrode. If additional metal is not required in the weld, a carbon rod or some other non-melting electrode is used. The electric-arc welder may also start motor generator and adjust current flow.

Resistance Welding

Resistance welding, as in "bar", "spot" or "seam" welding, is in reality a machine process. Two electrodes are clamped about the parts to be welded and an electric current is allowed to flow through them. Since resistance to the flow of current produces heat and resistance is always greatest at the point of poorest contact (that is at the break in the metal), it is here that the metal heats quickly to its melting point with resultant fusion. The welder may mechanically adjust the electrodes to compress tightly together the parts being welded to further ensure a sound weld.

Thermite Welding

The thermite welding process differs from other methods of welding in that a superheated metal compound is the agent used to promote coalesence. This compound, consisting of aluminum, iron and other elements, generates great heat when ignited and is poured around the preheated parts to be welded. Pressure may or may not be used. Filler metal, when necessary, is obtained from the liquid compound. Thermite welding is employed mainly to repair large units of iron and steel, such as railroad rails, locomotive frames and other large metal objects.

Cold Pressure Welding

This process differs greatly from the oxyacetylene, resistance, electric-arc and thermite processes for three reasons: (1) there is no melting of the parts to be joined; (2) no third metal is introduced into the weld; (3) pressure is used instead of heat to bring about coalesence. This pressure is applied by means of tapered or flat surfaced rollers or a combination of the two. A punch and anvil combination is another method used to apply the necessary pressure. Of utmost importance in the cold welding process is the proper cleaning of the metal to remove the oxidized layer on the surfaces to be welded. A combination of chemical cleaning and wire brushing or grit blasting and wire brushing are the methods most commonly used to obtain the desired results. When clean, the parts to

Photo: N.F.B.

Learning to do a simple welding job.

be welded are brought together between rollers. The extreme pressure exerted by the rollers push the atoms of one surface into the atom structure of the other surface so that the interface between the two is eliminated completely.

QUALIFICATIONS

A youth considering entering this occupation should be in good health. Welders require, among other things, good eyesight, a steady hand, good muscular control and the ability to lift moderately heavy objects.

While there are no specific educational requirements, technical and trade school welding courses that offer instruction in welding principles, practical blue-print reading, shop mechanics, etc. would be very helpful.

Although many women were engaged in production welding during the war, the number of female welders in post-war industry has decreased sharply. At the present time they represent only 2 per cent of the total number of welders in Canada.

Additional study by means of extension or part-time courses in metallurgy, with particular reference to the metallurgy of welding, would be of distinct advantage as a further qualification for promotion to supervising welding positions. The Canadian Welding Bureau, a branch of the Canadian Standards Association, sponsors suitable courses for welding supervisors. All welders employed by certified welding firms must be certified as qualified operators by the Canadian Welding Bureau, and supervising staff must have completed the Canadian Welding Bureau course or an equivalent.

TRAINING

Instruction courses of the type offered in trade schools include theory and shop practice in making various types of welds, using either electric or gas welding equipment or both. Advanced courses may include instruction in brazing, cast iron welding, aluminum welding and metallurgy.

Welding courses may also be provided by establishments which employ large numbers of welders on a production basis, such as shipyards. Such courses vary in length and content—from those designed to train workers to perform simple production welding tasks in the shortest possible time, to those intended to provide skilled, all-round welders capable of supervising other workers. The period ordinarily required to train adequately skilled workers may vary from three to twelve months; in some plants a three-year training program is followed.

Facilities for pre-employment training or upgrading of welders is provided under federal-provincial agreements in all provinces by the Departments of Education, except in the Province of Quebec where training is administered by the Department of Social Welfare and of Youth.

The length of courses varies from province to province and from short, upgrading courses to courses up to one year in length.

Details concerning courses of training may be obtained in each province by consulting local educational officials or by communicating with the Provincial Department of Education.

ENTRY

Prospective welders should investigate training facilities provided by Departments of Education, training programs in industry, and should take advantage of the services rendered by the offices of the National Employment Service in seeking openings where thorough training would be afforded.

EARNINGS

Tables of average wage rates for welders in various industries where large numbers of welders are employed are shown in "Wage Rates, Salaries and Hours of Labour in Canada", published annually by the Department of Labour, Ottawa.

ADVANCEMENT

The opportunities for advancement are limited. Where several welders are employed there may be the opportunity to advance to foreman or inspector.

RELATED OCCUPATIONS

Some forge and foundry work is related to welding. Blacksmiths using forge, hammer and anvil were the original welders. It should be kept in mind, however, that for a welder to enter another occupation where welding is one of the skills required, for example, automobile body repairing, he would be required to have some basic experience in automobile repair work in addition to his knowledge of welding.

ADVANTAGES AND DISADVANTAGES

Welders receive the benefits of coverage by unemployment insurance and workmen's compensation. Another advantage is that a welder requires only a fairly small financial outlay to open a job-welding shop should he decide to go into business for himself.

The chief disadvantage is the possibility of receiving burns, eyestrain (welder's flash), electric shock, falls from scaffolds or breathing in harmful fumes, generated from the gases used in the welding torch, which may cause throat and chest irritations. It should be clearly understood however, that all of these hazards can be guarded against by the wearing of suitable clothing, the use of protective equipment, plus ordinary care and common sense.

ORGANIZATIONS

Welders have no particular craft union of their own, but many are members of a union appropriate to the industry in which they are engaged.

TRENDS

Number of Welders in Canada

According to the Ninth Census of Canada, there were 23,649 welders and flame cutters in 1951, made up of 23,162 men and 487 women. This is almost twice the number that were reported in 1941, when 12,134 welders and flame cutters were listed.

This increase is due to a number of reasons: (1) defence production is still making heavy demands on industry; (2) construction, with its attendant need for steel products, is enjoying a high level of activity; (3) the iron and steel products group of the manufacturing industry, where many welders are employed, has grown tremendously both in size and importance during the last decade. However, many of those classified as

Photo: N.F.B.

A pipe welding job.

welders were machine operators who could perform only one type of welding, and thus could not be considered as competent, all-round welders.

GEOGRAPHICAL DISTRIBUTION

The distribution of welders in Canada, according to the 1951 Census of Canada, is shown in the following table:

REGIONAL DISTRIBUTION OF MALE WELDERS IN CANADA, 1951.

Maritimes	Quebec	Ontario	Prairies	British Columbia
1,170	5,675	11,539	2,996	1,782

INDUSTRIAL DISTRIBUTION

Workers in this occupation in 1951 were distributed among the various industries as follows:

Iron and Steel Products	9,164
Boilers, Engines & Machinery	3,853
Automobiles and Cycles	2,603
Construction	1,596
Other Iron Products	1,478
Shipbuilding and Repair	1,435
Railway Rolling Stock Mfg.	1,318
Sheet Metal Products Mfg.	888
Farm Machinery & Implements	831
Trade (Wholesale & Retail)	631
Electrical Prod. Mfg. and Repair	604
Steam Railways	444
Mining	705

The remainder of the welders were distributed over a wide variety of industries.

FUTURE OUTLOOK

As has been noted, welders are employed in many branches of industry. This provides a wide base for employment. Defence production, the manufacture of durable goods (i.e. industrial machinery, heavy electrical equipment, motor vehicles), and construction projects will continue to provide employment for considerable numbers of welders. Activity in any of the major fields listed above, as well as in other branches of industry is of course subject to changes which cannot be foreseen.

While activity is, as noted previously, at a high level the demand for welders will not likely increase proportionately because the increasing use of automatic welding machines reduces the number of welders needed.

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AUDIO-VISUAL MATERIAL

Readers desiring information on film sources, available materials and the organization of local film services, may obtain it from the National Film Board offices as listed in Monograph 1, entitled "Carpenter".

LOCAL INFORMATION

"CANADIAN OCCUPATIONS" SERIES

The monographs listed below, accompanied by pamphlets, except in the case of numbers 12 and 13, have been published to date. Those from 20-35 have been published collectively.

(1) Carpenter

(2) Bricklayers and Stone-Masons

(3) Plasterer

(4) Painter

(5) Plumber, Pipe Fitter and Steam Fitter

(6) Sheet-Metal Worker

(7) Electrician

(8) Machinist and Machine Operators (Metal)

(9) Printing Trades

(10) Motor Vehicle Mechanic and Repairman

(11) Optometrist

(12) Social Worker

(13) Lawyer

(14) Mining Occupations

(15) Foundry Workers

(16) Technical Occupations in Radio and Electronics

(17) Forge Shop Occupations

(18) Tool and Die Makers

(19) Railway Careers

Careers in Natural Science and Engineering: (20-35)

(20) "Agricultural Scientist"

(21) "Architect"

(22) "Biologist"

(23) "Chemist"

(24) "Geologist"

(25) "Physicist"

(26) "Aeronautical Engineer"

(27) —

(28) "Chemical Engineer"

(29) "Civil Engineer"

(30) "Electrical Engineer"

(31) "Forest Engineer and Forest Scientist"

(32) "Mechanical Engineer"

(33) "Metallurgical Engineer"

(34) "Mining Engineer"

(35) "Petroleum Engineer"

(36) Hospital Workers (Other than Professional)

(37) Draughtsman

(38) Welder

DEPARTMENT OF LABOUR

Economics and Research Branch

OTTAWA, 1955

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CANADIAN OCCUPATIONS

CAREERS IN HOME ECONOMICS

MONOGRAPH 39

DEPARTMENT OF LABOUR, CANADA

CANADIAN OCCUPATIONS

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CAREERS IN HOME ECONOMICS

MONOGRAPH 39

HON. MILTON F. GREGG, V. C., MINISTER
A. H. BROWN, DEPUTY MINISTER

DEPARTMENT OF LABOUR, CANADA

PRICE: 10 CENTS

FOREWORD

During recent years there has been a steadily increasing demand for up-to-date information on occupations.

This demand comes from youth faced with the need of choosing an occupation and of selecting the type of training required; from parents, teachers and other counsellors; from workers shifting to other occupations; from employment service officers; from directors of personnel and union officials, and from other quarters.

This series of monographs and an accompanying series of pamphlets, the latter containing similar information in a condensed form, are attempts to meet this demand. These publications are designed for general use and cover a wide range of occupations, including professions. They indicate, among other things, the nature of the occupation or group of occupations, entrance and training requirements, working conditions and opportunities in each.

The staff of the Occupational Analysis Section has prepared this series with the generous assistance of representatives of management, trade unions, and professional associations. The cooperation of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour, and the Dominion Bureau of Statistics is gratefully acknowleged.

Acknowledgment is also made of the assistance obtained from numerous publications on occupations prepared in Canada and in other countries.

DIRECTOR,
Economics and Research Branch,
Department of Labour.

March, 1956.

CAREERS IN HOME ECONOMICS

HISTORY AND IMPORTANCE

The art of homemaking has been practised by women ever since man began to live in shelters or homes. In pioneer times in Canada, the home had to be self-sufficient for most of its needs. Food, clothing, and many of the furnishings were made in the home by women who had only the simplest of equipment to aid them. Mothers proudly taught their daughters the art of homemaking, giving them the benefit of the knowledge they had gained through experience.

As Canada developed industrially, the home became much less self-sufficient. It was found that many foods and household articles could be more easily produced outside the home and this gave rise to new industries catering to the needs of the housewife.

At the turn of the century, women in increasing numbers were beginning to work in offices, stores and factories, so that less time was spent in the home and it became more difficult for girls to learn homemaking in the traditional way.

Because of the need for training in homemaking, classes in home economics were established and trained teachers provided for them in every province in Canada.

Home economics as a profession soon came into its own. The teaching of home economics in the schools, the tendency for modern housewives to seek expert advice in homemaking, and the desire of industry to produce a wide variety of household goods that would be attractive to the housewife resulted in an increasing demand for university-trained home economists. Another factor has been the rapid development of science in the twentieth century which made itself felt in the home in the form of better quality foods, clothing, household equipment, and labour-saving devices. Trained home economists were, and are, needed to interpret the part that scientific research plays in homemaking.

In more recent times, the number of women employed in industry has increased greatly. The changed attitude of employers

towards the hiring of married women, coupled with the high cost of living which compels many of them to seek paying jobs outside the home, accelerated the entry of women into the labour force and resulted in a demand for more household labour-saving devices and services.

The professional home economist is trained to advise homemakers in the selection of food, clothing, and household equipment, on new developments and ways of doing things, and on family care. Industry, too, has need of the knowledge of the home economist, so that it may better provide the goods and services required in the home. The teaching of home economics in the schools is now commonplace and has made for an increasing need for professionally trained home economics teachers.

The emphasis placed in modern times on the importance to health of diet and nutrition led home economists to specialize in dietetics and nutrition. The first hospital dietitian in Canada was employed by the Sick Children's Hospital in Toronto in 1907. To-day, dietitians are employed not only in hospitals but in industry and government as well.

A growing field of work for the home economist is in government service, at the municipal, provincial and federal levels. Home economics extension workers, for example, are employed by government agencies to instruct groups and individuals, particularly in the rural areas, in such things as homemaking, family living, and handicrafts.

In terms of numbers, this profession is not a large one, but it has been characterized by steady expansion. All told, it is conservatively estimated that some 1,600 university-trained home economists are employed in Canada to-day. Included in this total are over 1,000 professionally qualified dietitians; in 1935 there were only 200 in the whole of Canada.

Opportunities for the home economist are numerous and varied. The high turnover in the profession because of marriage adds to the opportunities awaiting young women interested in entering this stimulating and varied field of work.

NATURE OF WORK

There are six major fields of work open to the home economist :

1. Dietetics
2. Nutrition
3. Teaching
4. Extension Work
5. Research
6. Business

1. Dietetics

Dietitians form the largest group of workers within the field of home economics. They are employed in hospitals, particularly large ones, commercial and industrial restaurants, schools and colleges, day nurseries, clubs and summer resorts, and in the Armed

Photo : N. F. B.

Many dietitians are employed in hospitals.

Services. Certain manufacturers of food products and large retail food chains employ dietitians to experiment with recipes, to test their products and, in some cases, to demonstrate these to the public.

The dietitian is engaged primarily in the feeding of groups or individuals. She is a trained specialist who uses the findings of scientific research to encourage good nutrition and healthful food habits. Through diet, she endeavours to maintain and improve the health of the well, to aid in the recovery of the sick, and to prevent deficiency diseases.

The dietitian is responsible for the preparation and service of meals in large quantity. She takes charge of the planning, purchasing, storing, preparing and serving of foods. Before meals leave the kitchen, the dietitian checks to see that they are tasty and attractive. She is also responsible for the employing, training, and supervising of the various workers required to assist her in the work, and for the economic purchasing of food and equipment.

The dietitian must be a good administrator.

The work in hospitals is both varied and exacting. Regular meals must be prepared for both patients and staff, as well as for many individual patients requiring therapeutic diets. Where the institution is large, there may be some specialization and the dietitian may be employed in a particular department. In such cases, there may be a head dietitian and a number of qualified dietitians who are responsible to her. Sometimes a group of small hospitals will use the services of a dietitian consultant to administer and supervise their catering services.

Dietitians in restaurants, hotels, clubs and other eating places must think in terms of the type of service required and the desires of the clientele they wish to attract.

The qualified dietitian in the Armed Services is granted a commission on enlistment. In the Navy and Army she is employed primarily in hospital food services. In the RCAF she is utilized at all levels of responsibility for the provision of food in hospitals and for general and special feeding of air crew and personnel. In addition to supervising the planning, purchasing and serving of foods in messes, she is responsible for flight feeding, preparation of special and survival rations for air crew, and for foods shipped to isolated units.

2. Nutrition

The nutritionist is also concerned with food. She interprets the principles of nutrition to individuals and groups, and strives to educate the public in good eating habits by means of talks, publications and posters. Nutritionists are responsible for the solution of many consumer problems, which may entail conducting laboratory experiments to determine the nutritive value of foods. During the Second World War, nutritionists carried out programs to determine how rationed foods could best be used. They have also made various studies to establish balanced diets for different income level groups.

Nutritionists are employed by municipal, provincial and federal government agencies, by universities and by some newspapers, magazines and commercial firms.

3. Teaching

About one-third of all professional home economists are employed as teachers in elementary and secondary schools and in colleges and universities. Home economics as a school subject is taught in most parts of Canada.

Teachers in elementary schools give instruction in foods that are required for good health, health habits, elementary sewing and handicrafts, and the girl's role in family life; they also give practical instruction in meal preparation, making clothes, and home care.

A teacher in a smaller school may teach home economics along with other subjects. In some cases, a teacher may be employed to instruct in home economics in a group of schools.

At the secondary school level, teachers give theoretical and practical instruction in one or more branches of the subject. There is more specialized teaching, since secondary schools with large home economics departments may have separate divisions for the study of nutrition and food preparation, textiles, sewing and millinery, handicrafts and general home management. Secondary schools usually have practice kitchens, laundry and dining areas and sewing rooms for practical instruction purposes.

Courses in secondary schools are more advanced than those in elementary schools, and include the study of foods, clothing,

Photo : Kincardine District High School

Many schools have well-equipped home economics rooms.

textiles and other materials, home budgeting and purchasing, home furnishing, the efficient use of home appliances and equipment, child care and development, and family living. Home management principles, with emphasis on the health and well-being of the family, have an important place in the program.

The secondary school home economics teacher may be required to instruct adult classes at night school. In smaller schools, she may have to share in the teaching of such subjects as history, English, French, and mathematics.

In universities and colleges, teachers specialize in a particular phase of home economics.

4. Extension Work

Government agencies, particularly those having to do with

agriculture and fishing, as well as certain universities, employ professional home economists as extension workers to carry out educational and promotional programs, especially in rural areas. The extension worker conducts her work through such organizations as the Women's Institute, Cercles de Fermieres, 4-H Clubs, and church and school groups.

The extension worker is provided with quarters, where she carries on experimental work and attends to correspondence and enquiries. From there she will go out to schools, churches or community halls, where she sets up her equipment for talks and demonstrations. The program covers a wide range of topics, such as food and nutrition, home decorating, colour and design, styles, child development, and handicrafts.

Photo : N. F. B.

Extension workers carry out educational and promotional programs in rural areas.

The extension worker may carry out programs to popularize particular Canadian foods, such as fish, honey or cheese, by means of demonstrations and the preparation of cook books and pamphlets.

Although travelling and long hours may be expected by workers in this field, the extension worker achieves a unique status as an adviser on homemaking.

5. Research

Home economists with a keen interest in scientific research are employed to conduct research in food, nutrition, textiles, household equipment, soaps and detergents, food processing, and in other related fields. Such research is carried on by universities, hospitals, government agencies, and commercial firms.

Research work includes the development of new products and processes and the performing of a wide variety of tests to ensure safety and conformity to established standards. Long-range projects in specific areas, such as the preservation of foods by freezing, are also carried out. Another example is in the field of textiles where research workers develop new finishes and determine the wearing quality of fabrics and the means of caring for them.

Most research workers qualify for this type of employment by taking post-graduate university training in a particular field of research.

Textiles are examined and tested. Photo : N. F. B.

6. Business

Home economists in the business field are directly employed, or consulted, by manufacturers of food, furnishings and clothing, department stores, advertising agencies, magazines, newspapers, television and radio. Acting as a consultant, the home economist may, for example, present to the manufacturer the woman's point of view in the matter of design, colour and utility in household furnishings. She may be an adviser on interior decorating, home furnishings, or fashions for a large store. Some home economists demonstrate foods or appliances.

Many newspapers carry features of interest to women which are written by home economists. Advertising agencies also require women with this training to prepare copy for newspapers and magazines. A flair for writing is essential in both these areas.

Television and radio offer some opportunities to home economists who have the personality and talent for this type of work. It is not an easy field to enter.

QUALIFICATIONS

Before deciding to undertake professional training in this field, a girl should consider whether she has the personal qualities that are important in the home economist. Good health, good grooming, poise, enthusiasm for the work and an interest in people are some of these qualities. In almost all branches she will need tact, and the ability to meet people and to gain their co-operation. Common sense, adaptability and imagination are important. A pleasing voice is an asset, but more important is the ability to speak and write in a clear and interesting manner. The happy knack of being able to command the attention of an audience is most desirable in home economists who have to meet the public.

The interested student must be capable of taking university training. A particular interest in science subjects is important, since a sound knowledge of chemistry, biology and physics is needed in this profession. Universities teaching home economics require secondary school graduation with good standing in science subjects.

Business training is an asset and, in some fields, administrative ability is a necessity. An aptitude for teaching is desirable in almost all phases of the work, whether it be classroom instruction, staff training, or extension work.

TRAINING

Professional status can be attained only through prescribed university courses.

Well before the final year in high school, the interested student should check the subjects that are required for entrance to the university of her choice.

Home economics is a four-year course. Science courses form an important part of the curriculum, particularly in food and nutrition studies. Classes in such subjects as English, psychology and economics, provide the home economist with a cultural background that will be of value to her both from a personal and career point of view.

In the classroom, laboratory and practice rooms, students are given instruction in such subjects as food preparation, home decorating, household equipment, textiles and design, clothing, household management, child development and family relations.

Well-equipped kitchens and the latest in cooking aids are provided. Students are taught how to shop, plan, and prepare and serve meals that are attractive, wholesome and economical.

Experiments are conducted in food chemistry, in order that the student may learn about the changes that take place in foods under certain conditions. The essential food elements required for regular or therapeutic diets are also studied.

Instruction is given in the techniques of quantity food preparation. This involves the use and care of large ovens, mixers and other equipment, estimating food requirements, purchasing and budgeting of food and supervision of staff.

In the classes on clothing, students learn to choose materials, create designs and make their own clothing.

Home decorating courses teach the students the elements of interior design and decoration so that they may be better able to make appropriate selections of furnishings and accessories.

Textiles are examined and tested to determine their characteristics. Using the microscope, chemicals and other aids, students learn to check fibre content, evenness of thread, tensile strength and the quality of dyes used.

Infant and child care forms part of the training. The role

of the home economist in helping children to grow up into happy, well-adjusted adults is receiving greater emphasis.

Many students seek summer employment related to their university course. In this way they gain valuable practical experience and, at the same time, earn money to help defray the cost of university training.

Specialized training starts in the third or fourth year, depending on the university. By that time the majority of students will have decided whether to major in (1) Dietetics and Institutional Administration, (2) Teaching, or (3) Clothing, Textiles and Design, and will devote their time to the subjects that have a direct bearing on their future field of work. Students can, of course, continue with the general course in home economics, if they do not wish to specialize.

In the French universities in Quebec, there are no "majors" during the four-year course. Those who want to specialize must complete the full course first, and then do post-graduate work.

The university education of a dietitian must be followed by a ten to twelve-month "interneship" at an approved hospital or other establishment, under the guidance of qualified dietitians. This period gives the dietitian an opportunity to gain experience under regular working conditions.

The home economist who wishes to become a teacher must also have teacher training. In some provinces this training may be taken in the final years at university; in others, the graduate must attend a teachers' training college for one year. Students may, in some instances, be certified as teachers by attending summer sessions at a teachers' training college.

Training does not stop with the receiving of a degree. It continues for as long as one is engaged in the profession. The home economist must be prepared to spend a great deal of time in keeping up with new developments.

The following is a list of universities and colleges that grant degrees in home economics:

Acadia University, Wolfville, N.S.
Mount St. Vincent College, Halifax, N.S.
St. Francis Xavier University, Antigonish, N.S.
Mount Allison University, Sackville, N.B.

Macdonald College, Ste. Anne de Bellevue, P. Q.
University of Montreal, Montreal, P.Q.
Laval University, Quebec, P.Q.
Ottawa University, Ottawa, Ont.
(commencing September 1956)
University of Toronto, Toronto, Ont.
Macdonald Institute, Guelph, Ont.
University of Western Ontario, London, Ont.
University of Manitoba, Winnipeg, Man.
University of Saskatchewan, Saskatoon, Sask.
University of Alberta, Edmonton, Alta.
University of British Columbia, Vancouver, B.C.

ENTERING THE OCCUPATION

Entry may be made, after graduation, through contact with the university placement officer or the Executive and Professional Division of the National Employment Service, through personal application to an employer, through the professional organizations, or by reading newspaper advertisements. Those interested in openings in the federal or provincial government service should watch for notices of competitions, which are posted from time to time in universities and public buildings.

EARNINGS

Starting salaries compare favourably with those paid to other workers with similar educational background. Salaries will increase with experience and responsibility. Some home economists rise to positions where the remuneration is relatively high. Additional income may be derived from the sale of books or magazine articles.

Teachers' earnings will be in line with those paid to specialists in other school subjects. There will be considerable variation, depending on the teacher's qualifications, responsibilities and school location.

ADVANCEMENT

Promotion and increased remuneration will depend upon experience, application and willingness to assume responsibility and supervision. Some home economists will move into administrative positions in government. These are positions with varied and interesting duties. Executive positions are also to be found in hos-

pitals, restaurants, industry, and in world organizations, such as FAO and UNESCO.

Teachers in elementary schools may qualify, by further study, for positions in secondary schools or for positions in larger schools where salaries and working conditions may be better. Some may become heads of home economics departments with supervision over other teachers, or provincial school inspectors.

Home economists may also go into business for themselves or become consultants to industry.

Research workers may progress to more advanced positions in research or in administration.

RELATED OCCUPATIONS

Any area of work that has a bearing on homemaking will be a potential field of employment for the home economist. Consequently, she may relate her work to many industries. With additional training, the home economist can go into social service or welfare work, or enter the artistic field of designing materials, furniture or household equipment.

ADVANTAGES AND DISADVANTAGES

The field of home economics is so new that a person has ample scope to develop ideas and to explore new and interesting areas of work. Technological advances and new ideas make for change and variety in the profession. This means, of course, that one must spend a great deal of time in keeping abreast of new developments.

In some positions the nature of the work necessitates irregular hours and travelling.

Teachers work a relatively short day and a ten-month school year. Preparation of lessons and marking papers, however, take up a good deal of time outside of regular working hours. Attendance at summer school, in order to gain additional training, is common practice. Many will be expected to teach one or two evenings a

week, for which they will receive additional remuneration.

One cannot overlook the fact that the training and experience gained is an excellent background for homemaking and for leadership in community life. Many continue to work after marriage, and those who leave the profession have little difficulty in resuming their career at any time.

ORGANIZATIONS

There are two national organizations in Canada — the *Canadian Home Economics Association,* in which workers in all branches of the occupation may have membership, and the *Canadian Dietetic Association,* which restricts its membership to university graduates in home economics who have had the necessary interneship or experience. Both these organizations are active on behalf of their members and publish journals that keep the membership informed of current developments. Teachers may also belong to a teachers' federation.

EMPLOYMENT PROSPECTS

A large proportion of the job openings for home economists are in areas where there is a high concentration of population. There are more opportunities for employment in the larger cities, for it is here that the usual opportunities for home economists in hospitals and schools are augmented by those in government, university, and industry. There are, however, openings for home economists even in small communities in the fields of teaching, hospital work and, in some cases, industry.

The home economist may move freely from one part of Canada to another as opportunities present themselves. Teachers, however, since they hold a certificate to teach in a particular province, are more restricted in this respect.

Governments, communities, welfare organizations, and individuals are becoming more interested in better food utilization, in the relative value of many household commodities that are now on the market, and in good health habits. The many programs now in progress, calling for the services of home economists, and

others that will be undertaken in the future to meet the needs of a rapidly expanding population, will tend to contribute to a greater need for people in all branches of this profession.

At present, there is a shortage of dietitians, particularly in the hospital field. This is becoming more acute as hospitals expand and grow in number.

Teachers of home economics in primary and secondary schools are in short supply, and many schools have been obliged to hire teachers holding temporary certificates only. The demand for qualified teachers in all parts of Canada will increase as new schools are opened. Persons interested in this field of work should have little difficulty in becoming established.

There is every reason to believe that employment in the field of private industry, although relatively small at the present time, will increase as the economy expands and technological advances continue to be made.

Good opportunities are available in the Armed Services, particularly for dietitians.

The employment of experienced home economists as consultants or managers of such institutions as children's and old people's homes and reform institutions is becoming more frequent.

Because many home economists leave the profession in order to marry, there is a continual need for replacements.

For some years, at least, there should be ample job opportunities for home economists.

For girls with the required interests, aptitudes and abilities, there is good scope in this field for a life of personal satisfaction and service.

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PERIODICALS

Canadian Home Economics Association, *Canadian Home Economics Journal,* (quarterly), Box 55, 290 Vaughan Street, Winnipeg, Man.

Canadian Dietetic Association, *Journal of the Canadian Dietetic Association,* (bi-monthly), 415 Bloor Street W., Toronto 4, Ont.

LOCAL INFORMATION

LOCAL INFORMATION

"CANADIAN OCCUPATIONS" SERIES

Monographs and Pamphlets

The monographs listed below, accompanied by pamphlets, except in the case of numbers 12, 13 and 39, have been published to date.

(1) Carpenter
(2) Bricklayers and Stone-Masons
(3) Plasterer
(4) Painter
(5) Plumber, Pipe Fitter and Steam Fitter
(6) Sheet-Metal Worker
(7) Electrician
(8) Machinist and Machine Operators (Metal)
(9) Printing Trades
(10) Motor Vehicle Mechanic
(11) Optometrist
(12) Social Worker
(13) Lawyer
(14) Mining Occupations
(15) Foundry Workers
(16) Technical Occupations in Radio and Electronics
(17) Forge Shop Occupations
(18) Tool and Die Makers
(19) Railway Careers

Careers in Natural Science and Engineering: (20-35, one booklet)

(20) "Agricultural Scientist"
(21) "Architect"
(22) "Biologist"
(23) "Chemist"
(24) "Geologist"
(25) "Physicist"
(26) "Aeronautical Engineer"
(27) ———
(28) "Chemical Engineer"
(29) "Civil Engineer"
(30) "Electrical Engineer"
(31) "Forest Engineer and Forest Scientist"
(32) "Mechanical Engineer"
(33) "Metallurgical Engineer"
(34) "Mining Engineer"
(35) "Petroleum Engineer"

(36) Hospital Workers (Other than Professional)
(37) Draughtsman
(38) Welder
(39) Careers in Home Economics

Filmstrips

The Department of Labour has prepared, to date, the following occupational filmstrips in collaboration with the National Film Board. A manual has been prepared as an accompaniment to each filmstrip. These may be purchased from the National Film Board. Ottawa, or from any one of its regional offices.

Plumber, Pipefitter and Steamfitter
Careers in the Engineering Profession
The Social Worker
Technical Occupations in Radio and Electronics
Bricklayer and Stone-Mason
Printing Trades
Careers in Natural Science
Careers in Home Economics.

DEPARTMENT OF LABOUR

Economics and Research Branch

CANADA, 1956

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CANADIAN OCCUPATIONS

★

OCCUPATIONS IN THE AIRCRAFT MANUFACTURING INDUSTRY

MONOGRAPH 40

DEPARTMENT OF LABOUR, CANADA

CANADIAN OCCUPATIONS

★

OCCUPATIONS IN THE AIRCRAFT MANUFACTURING INDUSTRY

MONOGRAPH 40

HON. MILTON F. GREGG, V.C., MINISTER
A. H. BROWN, DEPUTY MINISTER

DEPARTMENT OF LABOUR, CANADA

PRINTED IN CANADA

Price: 10 cents

FOREWORD

During recent years there has been a steadily increasing demand for up-to-date information on occupations.

This demand comes from youth faced with the need of choosing an occupation and of selecting the type of training required; from parents, teachers and other counsellors; from workers shifting to other occupations; from employment service officers; from directors of personnel and union officials, and from other quarters.

This series of monographs and an accompanying series of pamphlets, the latter containing similar information in a condensed form, are attempts to meet this demand. These publications are designed for general use and cover a wide range of occupations, including professions. They indicate, among other things, the nature of the occupation or group of occupations, entrance and training requirements, working conditions and opportunities in each.

The staff of the Occupational Analysis Section has prepared this series with the generous assistance of representatives of management, trade unions and professional associations. The co-operation of the Unemployment Insurance Commission, the Vocational Training Branch of the Department of Labour, and the Dominion Bureau of Statistics is gratefully acknowledged.

In the preparation of this monograph, generous help was received from a number of aircraft manufacturing companies. Their contribution to this publication, in the way of advice and information, is greatly appreciated.

Acknowledgment is also made of the assistance obtained from numerous publications on occupations prepared in Canada and in other countries.

DIRECTOR,
Economics and Research Branch,
Department of Labour.

March, 1956.

Occupations in the Aircraft Manufacturing Industry

Photo: AVRO Aircraft Ltd.

Jet aircraft in flight.

HISTORY AND IMPORTANCE

In all human history, there have been few developments that have so universally captured, in so short a time, the imagination of mankind or have had such a profound effect on civilization as man's conquest of the air. In terms of travel alone, the globe has shrunk to a fraction of its size. The aeroplane has opened up vast new areas once isolated by terrain or time.

In the military sphere, emphasis has been placed on air power for national and international security purposes. The tension that has existed between nations in the post-war years and the development of nuclear weapons have led to a recognition in Canada, and elsewhere, of the need for a strong and up-to-date air force.

It was only 50 years ago that the Wright brothers made the first successful flight, short though it was, in a heavier-than-air machine at Kitty Hawk, North Carolina. Although the event received only brief, and often humorous, mention in the newspapers, it marked the beginning of one of the most exciting developments in modern times.

Man first flew across the Atlantic just 27 years ago, when Alcock and Brown took off from St. John's, Newfoundland, and pancaked into an Irish bog sixteen hours later. Since then three and a quarter million passengers have flown across the Atlantic. More than one thousand are now flying across the Atlantic every day.

Twenty years ago, a distinguished British engineer, lecturing in London on the "Limits of Human Flight", predicted that the absolute maximum speed for human flight was around 650 m.p.h. Many production military aircraft have already exceeded 750 m.p.h. — the speed of sound — and research aircraft have flown up to two and one-half times that speed.

These high speeds are the result of a phenomenal advance in power. From very crude piston engines of 25 hp. or less, we have moved to gas turbines that are already delivering 50,000 hp. and will soon be delivering considerably more.

The weight of aeroplanes has also gone up tremendously. At a meeting of the Royal Aeronautical Society in 1912, one authority stated that the maximum all-up weight of an aircraft would never be much more than 2,000 lbs. The CF-100, a two-place fighter 'plane, weighs about 36,000 lbs. A DC-7C, which carries 95 passengers, weighs about 130,000 lbs. fully loaded. On the drawing boards are much larger transports. And if development of an atomic aero-engine is successful, we shall probably see aircraft with all-up weights of half a million pounds.

Canada's Contribution to Aviation

For a country of relatively small population, Canada has made some substantial contributions to aviation. These go back to the beginning of flight at the turn of the century. The first major contribution was the aerodynamic research work in a wind tunnel built in New Brunswick by W. R. Turnbull, even before the Wright brothers took to the air for the first time in 1903. The Hon. J. A. D. McCurdy flew his Silver Dart 319 feet over the ice at Baddeck Bay in Nova Scotia in 1909. This was the first powered flight in the British Commonwealth.

Canada built 3,000 trainers in the First World War. Then the industry all but vanished. From 1923, until the beginning of the Second World War, activity was sporadic.

In the last 10 years, Canada has turned out 4,400 aircraft, the majority of which (3,500) have been produced in the past five years. During the past decade, eighteen different types of aircraft have been built in this country, ranging from small trainers to jet fighters and including four-engine commercial airliners, helicopters and a four-jet transport. Eight different types of aircraft are in current production, and the industry is getting ready to build two more; in addition, designing and tooling is in process on a supersonic delta-wing interceptor.

Operationally, we have seen our airlines jump from the Lodestar to the DC-3, to the North Star . . . to the Super Constellation . . . and now the turboprop Viscount. Remarkable progress has been made towards the popularity and general acceptance of air travel by the Canadian public. Just before the war, our airlines were carrying 100,000 revenue passengers a year. In 1954, they carried 2,800,000 such passengers — to Europe, Asia, Australia, South America and other countries. A similar increase in aerial transport of goods has occurred. In 1953, more than 177,000,000 lbs. of air cargo, express and freight were carried by Canadian commercial aircraft — a nine-fold increase over 1946. Trans-Canada Airlines and Canadian Pacific Airlines are two of the great commercial carriers of the world.

Aviation has played a vital role in opening up Canada's vast storehouse of natural resources. The pioneering role of the

intrepid bush pilot and of the private operator in opening up the hinterland is almost legendary. Without aviation, much of today's new mineral wealth might still be undiscovered or inaccessible. The aircraft played a big part in such recent developments as the Quebec-Labrador iron ore project, the Kitimat aluminum project in British Columbia, and the Beaver Lodge uranium find in Saskatchewan — the latter made Canada one of the most important uranium producers in the world. The pulp and paper industry utilizes the aeroplane to make air surveys of Canada's vast forest resources.

Aircraft Manufacturing in Canada - its Growth and Importance

The history of the operational side of aviation in Canada is well known. Not so much is known of the other phase — the industrial or manufacturing side. Today, Canada is

Photo: N.F.B.

Test engineer at a control panel runs a test on a jet engine.

counted among the first five top air powers, largely because of the swift development of the aircraft manufacturing industry in the post-war period.

In the design and production of the latest jet aero engines, airframes and armament systems, in the high quality of its engineering staffs, and in the production records which it has achieved, the aircraft industry has enabled Canada to take its place among the world's leading air powers.

The aircraft manufacturing industry is today an important part of Canada's economy, both in terms of jobs and in value of production. In 1954, the selling value of factory shipments for the aircraft and parts industry was almost $343 million. This placed the industry in ninth position among the leading manufacturing industries in terms of sales. The aircraft and parts industry had 35,000 employees in 1954 and ranked third in the manufacturing field in terms of numbers employed.

Although there was considerable aeronautical activity after the First World War, it revolved around the use of war surplus aircraft. There was little or no activity in the way of new aircraft construction until 1923, when a period of expansion began with the decision of the Department of National Defence to order eight single-engine amphibian flying boats as a preliminary to the re-equipment of the Canadian Air Force. It was felt that the time was ripe for the re-establishment of the aircraft industry in Canada, and the contract for these aircraft called for them to be "home-built". The first two machines were bought from England and the last six were successfully built at Montreal, and Canada's new industry was launched.

Leading aircraft and engine manufacturers, both in Great Britain and the United States, began taking steps to set up branches and agencies in Canada. By 1930, Canada already possessed a youthful aircraft industry. Up to the outbreak of the Second World War, it continued to expand slowly. In 1939, for example, it embraced 13 factories; the average total manpower was just over 3,500; gross selling value of products was about $12.6 million.

Then came the tremendous expansion during the Second World War. At the peak, 45 factories were operating and

nearly 80,000 people were employed. With the end of the war came contraction, as swift and spectacular as the expansion. At the lowest point, there were only 11 establishments in operation and the number of employees had dropped from 80,000 to 8,000.

Post-War Developments

But even at this point of low ebb, the Canadian government and the industry began laying the groundwork for a new, and what has proved to be a most important, chapter in Canadian aviation manufacturing history.

This new chapter began when A. V. Roe Canada Limited acquired the Malton facilities of the wartime Victory Aircraft from the federal government in 1945. Another major step, a few months later, was the acquisition of the Crown-owned Canadair Limited by what is now the United States' General Dynamics Corporation. DeHavilland Aircraft meanwhile swung into an active post-war program.

From this relatively small beginning has been built an industry which is much more self-sufficient than it has ever been. In the past, the types of aircraft made in Canada had been largely designed elsewhere, either in the United States or in Great Britain, and had a large non-Canadian content. The need for a greater measure of independence in the aircraft industry was brought home during the last war, when supplies of aeronautical equipment were cut off by enemy submarines and Allied home-front priorities.

Progress towards self-sufficiency has been marked in the past ten years. An important factor in this progress has been the stress laid on design and development, which is the heart of a basically sound aircraft industry. It was recognized as far back as the 1920's that aircraft designed elsewhere were not always suitable for use in Canada.

Design and development, and the broader goal of a more self-reliant aircraft industry, have been the most important factors in the rapid movement of Canada toward full aeronautical maturity.

Because of the emphasis placed on design and development, the employment of engineers in the aircraft industry has increased greatly. Ten years ago, it was estimated that one out of every 22 employees in Canada's aircraft industry could be classed as an engineer. Today the proportion is roughly one in ten.

An interesting comparison is the engineering man-hours involved in the original design and development of reciprocating engine fighters of the last war and jet-powered aircraft of the present time. It took some 42,000 engineering man-hours to design the wartime F-51 Mustang Fighter. It took 450,000 man-hours to bring along the CF-100 all-weather interceptor, from the first line on the drawing board to the first flight of the prototype. The development of the Orenda turbojet engine, which powers the CF-100 and the Sabre 5 and 6 built by Canadair, took over 500,000 engineering man-hours, at Malton, plus some 500,000 sub-contracted design man-hours on engine and accessories, and 650,000 design man-hours on jigs and fixtures.

The need for top engineering talent and skilled manufacturing personnel was emphasized soon after the war, when use of the great circle route over the North became the shortest practical course between Europe-Asia and North America. Defence of this vast, unpopulated frontier fell to the RCAF. In addition to the latest type fighters, the RCAF required a specialized defensive aircraft of a design not available in other countries.

These requirements resulted in Canadair Limited going into quantity production on the United States-designed F-86 Sabre, a first-line, high-performance day fighter. It underwent major engineering work at Canadair and was completely assembled from parts manufactured in Canada. The Sabre is in use by the RCAF in Europe and by a number of NATO air forces, including the RAF.

The special requirement resulted in Avro Aircraft's CF-100, a high performance, long-range, all-weather interceptor. Recognized as the outstanding aircraft of its kind, this bomber-destroyer is equipped with radar-actuated rocket armament,

and has been in service with the RCAF for over two years. The CF-100 became the first military aircraft to be completely designed, developed and produced in Canada.

Meanwhile, DeHavilland designed, developed and produced two cargo-passenger aircraft to meet the exacting small-lake and short-field demands of Canada's bush operators. One, the Beaver, has been sold in countries the world over. It won the approval of the U.S. Army and U.S. Air Force and became the first all-Canadian aircraft to be sold in quantity to the United States for military purposes. The other, the Otter, a larger aircraft for the same utility duties, has had similar world-wide and military success.

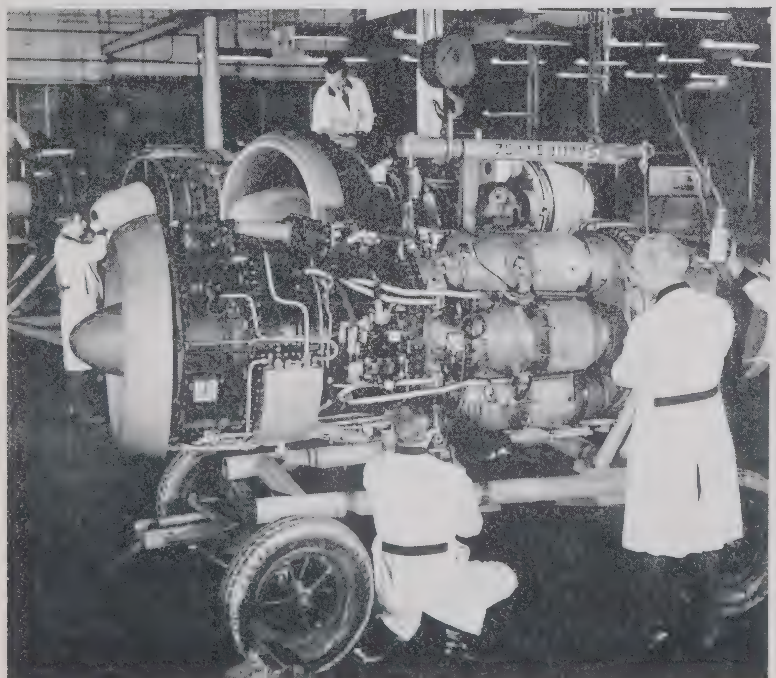

Photo: N.F.B.

A jet engine assembly line.

Jet operation in the RCAF demanded jet trainers. To meet this need, Canadair undertook quantity production, under licence, of T-33 Silver Stars. Elementary training requirements were taken care of by DeHavilland's production of its own Chipmunk, and Canadian Car & Foundry's production of Harvards and T-34 Mentors. The latter company also turned out Mentors for the United States Air Force.

Power plants for most of these aircraft have been made in Canada. Orenda Engines Limited, a subsidiary of AVRO Canada Limited, has supplied over 2,500 turbojet engines for CF-100's and F-86's. These production engines were completely designed, developed and built in Canada. Rolls-Royce established manufacturing facilities near Montreal to produce its British-designed Nene engine for Canadair's T-33. Canadian Pratt & Whitney became sole North American producer of one highly rated piston engine and Canadian licensee-producer of another.

Among the projects now in advanced stages in Canada's aircraft manufacturing industry are: Avro Aircraft's supersonic C-105 delta-wing interceptor; Canadair's four-engine CL-28 for maritime reconnaissance; DeHavilland, with Canadian Car & Foundry and Canadair as sub-contractors, will produce CS2F Sentinels for the Royal Canadian Navy; Bristol Aeroplane Company and Canadair are combining efforts for the construction of a commercial turboprop airliner; and a new Orenda gas-turbine engine with a five-figure thrust is also under way.

Aircraft Industry as a Field of Work

The Canadian aircraft manufacturing industry is an important user of engineers, scientists, technicians and skilled manpower. Its various projects and programs have an impact on many areas in Canada. Although the main facilities are located in the central provinces, near Montreal and Toronto, the network of sub-contractors and suppliers stretches from Halifax to the West Coast.

The core of the aircraft industry consists of seven firms, which are engaged in the production of either airframes (aircraft) or engines. These are listed below. In addition,

there are a large number of other establishments that are occupied solely or chiefly in making aircraft parts — in 1953, these numbered thirty-seven. All these firms, taken together, can be said to constitute the aircraft industry proper. There are, in addition to these firms, several hundred suppliers of aircraft parts and components, as well as a small number of companies fully equipped to deal with major aircraft repair, overhaul and conversion work.

Major firms engaged in the Manufacture of Aircraft and Engines

Aircraft (Airframes)

Canadair Ltd., Montreal

Avro Aircraft Ltd., Toronto

Canadian Car & Foundry Co. Ltd., Fort William, Ont.

DeHavilland Aircraft of Canada Ltd., Toronto.

Engines

Orenda Engines Ltd., Toronto (a subsidiary of A. V. Roe Canada Ltd.)

Pratt & Whitney Aircraft Ltd., Montreal

Rolls-Royce of Canada Ltd., Montreal.

What of the Future?

To a considerable extent the aircraft manufacturing industry depends on defence orders. In the past, this has unavoidably resulted in considerable instability of employment. As defence needs subsided, so did demands on the aircraft industry. The wartime peak employment figure of 80,000 as against the post-war low of 8,000 is a typical example of what happened.

International political developments still play an important role in the future of the aircraft industry. However, events of the last ten years have emphasized the need for maintaining a fully developed aircraft industry, one which will be ready to gear itself quickly to the heavy demands for aircraft in a time of emergency.

It is likely that activity in the aircraft industry will be maintained at or about the current level for some time to come, at least as far as defence requirements are concerned. This, coupled with increasing activity in the highly competitive commercial field, should enable Canada to maintain her position among the foremost aircraft producers of the world.

STAGES IN AIRCRAFT MANUFACTURING

In order to gain a general idea of what is involved in the making of an aircraft, a brief review of the aircraft manufacturing process will be helpful.

Design and Testing

The first stage concerns the *design and testing* of the prototype aircraft and its engines.

Engineers make calculations and analyses to determine the configuration of the aeroplane and the materials, systems and installations it contains; prepare manufacturing drawings and conduct tests to confirm calculated data and to prove satisfactory strength of the airframe and functional suitability of systems. *Draftsmen* and *technicians* assist the senior engineers in most phases of design and test programs.

Machinists, *machine operators*, *sheet metal workers* and *model makers* build the model parts.

A detailed master design is produced incorporating features found to be worthwhile and rejecting those that are apt to fail.

Tool designers specify the type of tooling that will be needed to manufacture the prototype. Actual construction of the tools takes place in the tool room.

The prototype aircraft and engines are then built. The prototype is thoroughly tested on the ground and in the air, faults are corrected and, after further testing, it is approved for large-scale production.

Production Planning

Now it is necessary to produce in quantity and to gear the facilities of the suppliers, the machine shops, and the assembly lines to meet anticipated requirements.

The planning of the details of production takes place in the company's Process Planning Department. The Engineering Department supplies it with drawings, data, blueprints, and lists of tools and specifications. *Process planners* prepare and issue instructions as to what operations are necessary to produce the finished parts.

The Standards Department estimates the time that will be required for each operation — *time-study men* calculate actual times.

The Production Control Department totals the times that will be necessary for all operations and prepares a schedule for the delivery of various parts to the final assembly lines.

Photo: N.F.B.

An electrician checks the wiring diagram of a jet accessory panel.

Purchasing personnel place orders for materials, award contracts for the manufacture of various parts and equipment, and follow up on these orders to ensure that the parts arrive in time to meet production schedules.

Tooling-Up

Tooling-up for large-scale production begins. This involves the manufacture and purchase of special tools, dies, machinery, jigs and fixtures.

Production

Engines and engine parts, wings and tail and fuselage, various instruments and equipment, and thousands of component parts for each of these are made and assembled either by the company itself or by sub-contractors. All parts are brought together for sub-assembly and final assembly.

Inspection personnel check each part, rejecting those that do not meet rigid specifications.

The completed aircraft and its engines are then flight tested and prepared for delivery.

Sales and Service

All that has to be done now is to keep the aircraft flying. This means that the Sales and Service Department must ensure that spares are available and that instructions are issued regarding oiling, greasing, replacing parts that are subject to wear, and the thousand and one contingencies that may arise in a variety of climates and operational conditions.

Illustrators and *writers* prepare pamphlets and bulletins that tell mechanics in the field what to do and when to do it.

Repair and Overhaul

After an engine or aircraft has been in use for a specified number of flying hours, it must be returned for overhaul. The Repair and Overhaul Department repairs or replaces worn parts, and performs final tests to ensure that all components are functioning properly.

NATURE OF WORK

Engineering Occupations

In aircraft development work, where plans and specifications are prepared for new aircraft and engines and their component parts, many scientific workers are employed — *aeronautical, mechanical, electrical, electronic* and *civil engineers, chemists, metallurgists, physicists,* and *mathematicians. Draftsmen* produce drawings of the various components, under the direction of engineers and designers. *Blueprint machine operators* run off blueprints for distribution to various engineering groups; and *clerks* keep track of technical information and make it available where and when required.

Laboratory and Test Occupations

Laboratory and *test technicians* assist senior engineers in the preparation of test programs, manufacture and servicing of instrumentation, conduct of tests, recording of instrument readings and preparation of test reports. Test programs include wind-tunnel, static and dynamic structural tests, mechanical, electrical, electronic, metallurgical, power plant and fluid systems.

Process Planning Occupations

Process planners work out the sequence of operations and processes necessary to make, assemble and install aircraft and engine parts. They are the link between the Engineering and Production Departments of the plant. The work calls for a knowledge of shop practices and manufacturing principles. For the most part, process planners are recruited from among draftsmen, skilled assemblers and machine-shop workers.

Tooling and Tool Design Occupations

The tooling-up process, as we have seen, precedes the actual production stage. In the tooling shop, tools, jigs, fixtures and dies used in the manufacturing of aircraft parts and components are made by skilled workers.

Even after production is in process, the tooling shop is still

Photo: N.F.B.

The "loft" where designs are proved before production is started.

an active place because of design changes, the need to renew worn-out tools and dies, and the tool demands of expanding production.

The lofting section of the Tooling Department receives blueprints from the Engineering Department. *Loftsmen*, using drafting tools, prepare drawings of aeroplane structural parts on loft boards of sheet metal or plywood. Photographic methods are also used to transfer lofts directly on to sheet metal. From these drawings, models are made by the *woodworker* and *patternmaker*. These provide a check on the design of the aircraft.

Master patterns, called templates, are prepared from the loft board drawings. These sheet-metal patterns represent actual aeroplane sections and are used as standards in production. *Template makers*, experienced in the use of hand tools and metal-working machines, are engaged in this work.

Jig and *fixture builders* lay out, construct and assemble work-holding devices used in production and assembly operations. These devices are usually made of wood or metal. In addition to holding in position the material worked on, a jig also guides the tools used in the process. Jig and fixture builders work from blueprints, sketches, and tooling templates and use machines, hand tools and precision measuring instruments.

Tool designers design the dies, cutting tools and fixtures of various types that are used in the manufacture and assembly of engines and aircraft components. They prepare drawings of the tooling required and pass these on to the tool room.

Tool makers and *tool and die makers* construct, repair and maintain machine-shop tools and dies used for forging, punching, stamping and other metal-forming work. They operate various machine tools, perform lay-out work, and assemble parts as necessary. They may also make jigs and fixtures.

A related occupation is that of *tool fitter*, who fits and assembles tools and jigs and, if necessary, reworks them by hand or machine.

Patternmakers build patterns of plaster, clay, metal, or other materials for use in making moulds from which dies and aeroplane parts are cast. Patternmakers also lay out and make mock-ups and models from prints, sketches, parts, drawings or templates. Bench tools, machine tools and precision measuring instruments are used in this work.

Standards Occupations

In order that component parts can all reach the sub-assembly and final assembly lines on schedule, and in the quantities desired, it is necessary to know the time that will be taken in producing them. *Time-study men*, using a stop watch, time each operation in sequence and total these times — allowances are made for fatigue and normal delays that would be encountered by the machine operators.

Estimators, using times that have been taken to perform operations in the past and figures on the capacity of available machines, produce estimated times in cases where it is not possible to time actual operations; these are checked for accuracy as soon as operations commence.

Standards Department personnel produce charts and graphs that illustrate degrees of efficiency that will be reached by changes in machinery and methods.

Time standards are also used by the Accounting Department in its calculations of final labour costs of aircraft components.

Production Control Occupations

The Production Control Department is responsible for producing the schedule of dates on which component parts must reach the assembly lines. *Schedulers*, many of them with accounting experience, prepare lists of parts and completion dates for various operations.

Shop expediters and *progress men*, who have a knowledge of the plant layout, try to ensure that parts arrive at each stage of operation within the time limits set out by the schedule.

Purchasing Occupations

Buyers in the Procurement Department send out tenders to various sub-contractors, advising them of parts and materials required and when they will be needed.

Expediters keep in touch with the suppliers in order to be fully informed on work in process and delays that may hold up production.

Personnel in the Purchasing Department usually have had previous experience in purchasing or production control and have gained a knowledge of materials from experience in the tool room, assembly shops or machine shops.

Foundry and Forging Occupations

In the foundry, molten metal is poured into sand moulds, which shape it into metal parts. Engaged in this work are *moulders*, *coremakers*, *casting cleaners*, *crane operators*, *furnacemen* and *inspectors*, among others.

In forging, metal is heated and beaten into shape by drop hammers, or pressed into shape by forging presses. Dies are used in both the hammering and pressing processes. The main occupations here are *drop-hammer operator*, *hammersmith*, *forging-press operator* and *heater*.

Machine Shop and Related Occupations

Some metal parts cannot be cast or forged and must be fabricated by machine. Castings and forgings are also finished by machine.

In the machine shop, iron, steel, magnesium, aluminum, and alloys of these, are used to make parts for all sections of the

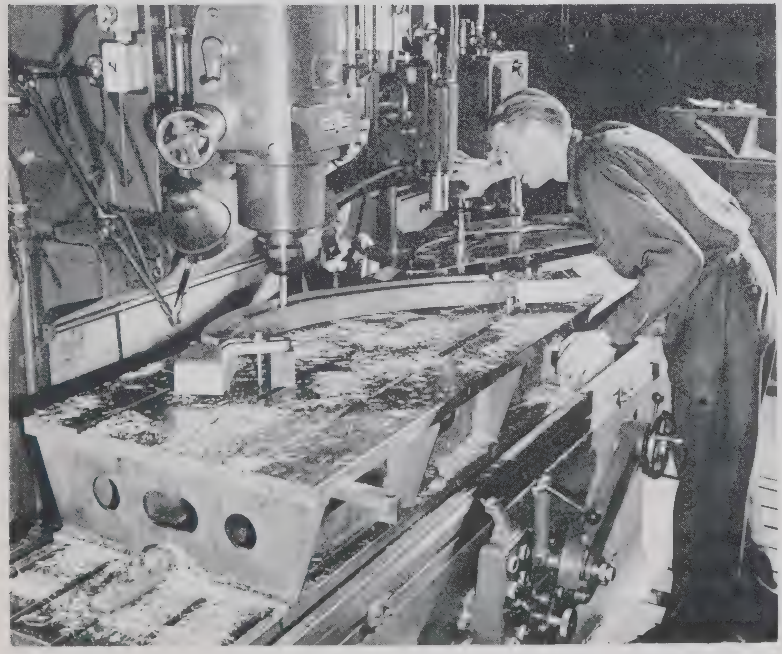

Photo: N.F.B.

Milling a bar of magnesium.

aircraft. Turret lathes, milling machines, engine lathes, bench lathes, grinders, drill presses and shapers are typical of the machines found in the machine shop.

Machinists and *machine operators* are the two main groups of workers found in the machine shop.

Machinists are skilled workers who lay out the work and set up and operate several types of machines. They perform machining operations on highly variable work, usually without supervision, and must be able to shape metal parts to precise dimensions within the close tolerances prescribed. Machinists lay out and machine complicated experimental, tool or production parts from tool design or engineering drawings or sketches. They must understand blueprints and written specifications and be skilled in the use of machinist's hand tools, including scrapers, chisels, files and measuring instruments. Of the utmost importance is a good knowledge of shop mathematics, the use of charts and tables, and the efficient planning of shop work. Familiarity with the working properties of such metals as aluminum, brass, cast and wrought iron, and various steels, is also necessary.

Machine operators are workers who usually specialize in work on a single type of machine. The more skilled operators set up the work on the machine, use precision measuring instruments, and may work without supervision. The less skilled operators have the work set up for them and work, under supervision, on more repetitive jobs than the former group. A knowledge of blueprint reading is desirable in all machine operators. Engine lathe and milling-machine operators are numerically prominent in aircraft work.

Grinders are skilled or semi-skilled workers who grind surfaces of tools and production parts. Grinding is, in most cases, a precision job, which calls for the setting up and operating of a variety of grinding-room equipment, and the use of precision measuring instruments. Blueprint reading is also involved.

Tube-bending-machine operators adjust and operate a machine that bends pipes or tubing to specified angles. Tubing

is used for hydraulic, pneumatic, and fuel lines. Metal tubing for use in aircraft hydraulic and electrical installations is sometimes bent by hand.

Also engaged in the fabrication of metal parts, particularly in airframe work, are *sheet-metal workers* who cut, bend, and shape sheet metal by hand and/or machine. Here again, the work varies in degree of skill required. In the hand process, the worker shapes the part by pounding it with a mallet, and bends, cuts, and punches it with hand tools. The all-round sheet-metal worker is a skilled tradesman. With the aid of blueprints, lofting data, and other engineering information, he lays out the sequence of operations, and fabricates by hand or power machine complicated and non-repetitive metal shapes. Repetitive production work is done by less skilled workers. Some production sheet-metal work is done by workers who specialize in operating single machines, such as the hydraulic press, forming press, punch press, power brake, power hammer, and power shear.

Rivetters join together aeroplane structural members, assemblies, sub-assemblies and small metal parts with various kinds of rivets. They drill and ream holes in metal, insert rivets and form the rivet heads using hand rivet sets and hammers, pneumatic rivetting hammers, and rivetting machines.

Welders weld together ferrous and non-ferrous metal aeroplane and engine parts, and repair and construct such equipment as engine test stands and jigs, using oxyacetylene or electric welding apparatus, or both. *Spot welders* and *seam welders* join together two or more overlapping pieces of metal by means of a spot-welding or seam-welding machine.

Other Machine Shop Occupations

Millwrights are primarily engaged in the installation of machines and equipment of any type. They may be also concerned with keeping the machines in a state of good repair.

Maintenance Mechanics are mainly concerned with keeping machinery and equipment in good repair.

Metal Processing Occupations

In metal processing work, metal parts are treated with chemicals to minimize corrosion and to provide paint-adhering surfaces. Other parts are heat-treated to harden or strengthen them, or to make them more machinable. Among the workers performing these operations are *heat treaters*, *anodizers*, and *electro-platers*.

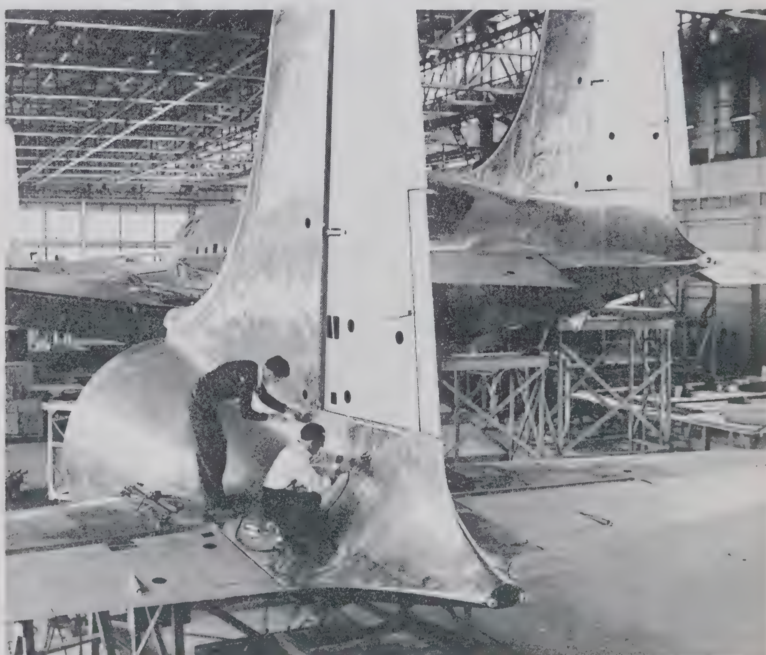

Photo: N.F.B.

Workmen put the finishing touches on a tail assembly ready for installation.

Assembling, Installing and Fitting Occupations

Assemblers constitute the largest occupational group in the aircraft industry.

Assembler is a general term used to designate a worker who assembles mechanical units or fabricated parts to form complete units or sub-assemblies, using hand tools. The assembler is usually designated according to the complexity of the work he is performing. Some assemblers are skilled workers, but the majority do relatively simple and repetitive work. The most skilled perform all the functions of fitting, assembling and installing, without the use of special tools; less skilled assemblers perform similar functions on repetitive jobs, where the necessary tooling is provided. Smaller parts are fitted together at a bench to form a unit. Larger parts and units are assembled on the floor to form structural parts, components, and completed aircraft or engines.

Assembly operations are also classified as detail and sub-assembly work, and major and final assembly work.

Detail assemblers assemble small aircraft and engine parts (detail assemblies) and equipment, such as ribs, fuel tank parts and junction boxes. These parts are joined together by *sub-assemblers* to form aeroplane structural parts and equipment, such as ailerons, bulkheads, door frames, spars and fuel tanks.

Major assemblers join together or assemble the component parts of aeroplane units or prefabricated sub-assemblies to form complete major assemblies, such as tail, wings and fuselage sections.

Final assemblers fit together all principal assemblies to form complete aeroplanes and install all necessary items needed for their operation. They hoist into place, align, fit and bolt together wings, tail and fuselage sections. Engine parts are attached to partially assembled aircraft engines, which are then installed in wings or fuselage, according to blueprint specifications. Final assemblers also install engine controls and hydraulic, flight control, and fuel and oil systems. They are responsible, as well, for installing propellers and disassembling aeroplanes for shipping.

Aircraft electricians are responsible for the installation, testing and repair of all electrical services in the aircraft.

Aircraft radio mechanics install, test, adjust and repair radio transmitting and receiving equipment. *Aircraft radar mechanics* are specialists who perform similar functions on radar equipment.

Inspection and Testing Occupations

The occupational group of inspectors and testers is a sizable one. All materials, parts, components, sub-assemblies and ancillary equipment that go into the making of the completed aircraft undergo inspection and testing.

Procurement or *receiving inspectors* inspect incoming, outgoing and production-line parts and materials for defects and for compliance to specifications. *Tool inspectors* check new and reworked dies, gauges, jigs, fixtures and precision tools before they are used by production workers, and inspect them in use to make sure they are maintaining their accuracy. *Bench-assembly inspectors* inspect aeroplane parts fabricated by bench assemblers or sub-assemblers. In this latter group, there are many specialists, such as *electrical-test inspectors, engine-and-hydraulic inspectors, structural assembly inspectors, radio testers* and *sheet-metal inspectors.*

Final assembly inspectors and *flight test mechanics* are skilled workers. The former inspect completed aeroplanes for defects of assembly and operation; the latter ground-test the completed aircraft prior to actual flying tests.

These are some of the numerous testing and inspection occupations. They vary much in required training and skill — from semi-skilled workers doing simple and repetitive checking and testing to specialists with long training and experience.

Sales and Service Occupations

In conjunction with the Engineering Department, personnel in Sales and Service prepare the graphs that illustrate the performance of the engine or aeroplane, speed and rate of climb, cruising speeds, fuel consumption and other characteristics. These features must be displayed on paper in order to show the prospective customer the real value of the company's product and to give him a yardstick by which he can compare it with others in which he is interested.

Personnel in the Spares Department draw up lists that show how long a part will last; others order parts from the Production Department, and package and store these for future use.

Technical writers, who usually have a background of assembly experience, prepare pamphlets that set out, in a form that the mechanic on a remote airfield can understand, the correct procedure for replacing parts and for oiling, greasing and fueling the aircraft and engine. *Technical illustrators* prepare illustrations, drawings, retouched photographs, and wiring diagrams that highlight the various parts that the mechanic must service or replace. They are also called upon to produce pictures from blueprints and sketches. Technical illustrators usually have an art school education background or drafting experience and a flair for art.

Repair and Overhaul Occupations

These are similar to those in the production shop. Here *planners* outline the operations necessary to repair and replace worn or damaged parts, and *sheet-metal mechanics, machinists* and *assemblers* carry out the operations.

Other Aircraft Occupations

The aircraft industry also employs *aircraft painters; woodworkers* who make wooden aircraft parts; *aircraft fabric workers; stock clerks* and *tool-crib attendants* who keep the production workers supplied with tools, parts and materials; *plant maintenance workers*, including carpenters, electricians, plumbers and pipefitters, painters and sheet-metal workers; a large number of *administrative* and *clerical workers*; and workers engaged in storage, transportation and shipping.

ENTRY, QUALIFICATIONS AND TRAINING

The qualifications for many of the occupations mentioned in the previous section are described in detail in other monographs that have been published in the "Canadian Occupations" series. A listing of these publications will be found on the inside back cover of this booklet.

Scientists and engineers are recruited from among university graduates in science or engineering. Previous experience is usually not required since most companies provide formal or on-the-job training. There is an increasing demand for en-

gineers with Masters or Ph.D. degrees in certain specialist fields such as high speed aerodynamics, and electronics.

Although preference would be given to experienced draftsmen, it is possible for graduates of a technical school course in drafting to enter this occupation and be trained on the job.

Production planning jobs call for workers who are either experienced draftsmen, skilled assemblers, machine-shop workers, or who have professional engineering qualifications.

Entry into the skilled trades, such as are found in tool making, foundry and forge shops, and in machine shops is usually achieved through a long period of apprenticeship. The length of the period may vary from two to seven years, depending on the trade.

Photo: N.F.B.

Transports near completion in the assembly line of an aircraft plant.

Less skilled workers learn their jobs in a shorter time — this may vary from a few weeks to two years — through training on the job. Technical school training is a very useful preparation for both groups.

There are numerous jobs in assembly and inspection work which provide a means of entry into aircraft work for persons with one or two years of technical or high school education. Opportunities for advancement are, however, very limited in these two areas of work. The skilled, technical and professional occupations offer much more in the way of advancement and steady employment.

Many of the machine operating, rivetting, and welding jobs are also entry occupations for workers with little or no experience. Others require from one to two years' on-the-job training. In the case of the more highly skilled operators and welders, training lasts for about three years.

Qualifications usually required for certain other workers in the aircraft industry are as follows:

Engine Experimental Mechanic — six to seven years' related experience to develop the necessary skills.

Aircraft Experimental Mechanic — five years' diversified aircraft manufacturing experience. A Department of Transport A & C Air Engineer's Certificate (1) may be required.

Aircraft Service Mechanic — four years' experience in engine and flight service work.

Aircraft Radio Mechanic — three years' experience in aircraft radio and electrical work for top mechanics; one year's experience in radio work for less skilled mechanics.

Aircraft Radar Mechanic — three years' experience in aircraft electrical and radar work.

Aircraft Hydraulic Mechanic — three years' aircraft hydraulic experience.

Instrument Mechanic — three years' experience in repair, testing and installation of aircraft instruments.

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(1) A & C Certificate — inspection of aircraft or engines before flight.

Aircraft Electrician — one year's experience in electrical work at the lower level; three years', at the higher level.

Tool Fitter — three years' fitting experience.

Engine Fitter — five years' experience. May advance to *Fitter Tester.*

Jig Builder — two years' experience for the lower positions; four years', for the more skilled jobs.

Tester — junior matriculation or equivalent. One year's test experience, or two years' general machine shop or aircraft engine experience at the lower level; four years' machine shop or experimental engine experience at the higher level.

Special Inspector (*Aircraft*) — must hold either an A & C or B & D Air Engineer's Certificate (1) from the Department of Transport.

EARNINGS

Average weekly earnings in the aircraft and parts industry are among the highest in the manufacturing field. On October 1, 1955, the average for all workers in this industry was $77 per week, compared with an average of $64 per week for all manufacturing industries (2).

Average hourly earnings for production workers on October 1, 1955, were $1.74 per hour, compared with $1.45 for all manufacturing industries. Average hours worked were 41.7 per week (3).

The reader is referred to "Wage Rates and Hours of Labour in Canada", published annually by the Department of Labour, Ottawa, for wage rates for selected occupations in the aircraft and parts industry.

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(1) B & D Certificate — inspection of aircraft or engines after overhaul.

(2) Dominion Bureau of Statistics, *Employment and Payrolls*, October 1955.

(3) Dominion Bureau of Statistics, *Man-Hours and Hourly Earnings*, October 1955.

LOCAL INFORMATION

LOCAL INFORMATION

"CANADIAN OCCUPATIONS" SERIES

Monographs and Pamphlets

The monographs listed below, accompanied by pamphlets, except in the case of numbers 12, 13 and 39, have been published to date.

(1) Carpenter
(2) Bricklayers and Stone-Masons
(3) Plasterer
(4) Painter
(5) Plumber, Pipe Fitter and Steam Fitter
(6) Sheet-Metal Worker
(7) Electrician
(8) Machinist and Machine Operators (Metal)
(9) Printing Trades
(10) Motor Vehicle Mechanic
(11) Optometrist
(12) Social Worker
(13) Lawyer
(14) Mining Occupations
(15) Foundry Workers
(16) Technical Occupations in Radio and Electronics
(17) Forge Shop Occupations
(18) Tool and Die Makers
(19) Railway Careers

Careers in Natural Science and Engineering: (20-35, one booklet)

(20) "Agricultural Scientist"
(21) "Architect"
(22) "Biologist"
(23) "Chemist"
(24) "Geologist"
(25) "Physicist"
(26) "Aeronautical Engineer"
(27) ——
(28) "Chemical Engineer"
(29) "Civil Engineer"
(30) "Electrical Engineer"
(31) "Forest Engineer and Forest Scientist"
(32) "Mechanical Engineer"
(33) "Metallurgical Engineer"
(34) "Mining Engineer"
(35) "Petroleum Engineer"

(36) Hospital Workers (Other than Professional)
(37) Draughtsman
(38) Welder
(39) Careers in Home Economics
(40) Occupations in the Aircraft Manufacturing Industry

Filmstrips

The Department of Labour has prepared, to date, the following occupational filmstrips in collaboration with the National Film Board. A manual has been prepared as an accompaniment to each filmstrip. These may be purchased from the National Film Board, Ottawa, or from any one of its regional offices.

Plumber, Pipefitter and Steamfitter
Careers in the Engineering Profession
The Social Worker
Technical Occupations in Radio and Electronics
Bricklayer and Stone-Mason
Printing Trades
Careers in Natural Science
Careers in Home Economics

DEPARTMENT OF LABOUR

Economics and Research Branch

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